PRELIMINARY REPORT OF RAINFALL EVENT, NOVEMBER 21-26, 1984 SOUTH FLORIDA COASTAL AREA

This public document was promulgated at an annual cost of $224.26, or $.45 per copy to inform the public regarding water resource studies of the District. RP 1088 50

Water Resources Division
Resource Planning Department

Operations Division
Resource Operations Department

Field Engineering Division
Resource Control Department

South Florida Water Management District

December 1984

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

List of Figures - continued

HYDROMETEROLOGICAL ANALYSIS

I. Description

An intense low pressure center remained nearly stationary off the Palm Beach County coast November 22 (Thanksgiving Day) and November 23 causing heavy rains, strong winds, local flooding, and severe beach erosion in eastern Palm Beach, Martin, St. Lucie, and Indian River Counties. Winds and rains tapered off Saturday, November 24 as this low pressure center moved slowly off to the northeast. More than 19 inches of rain were measured west of Jupiter (Cree Street) by a Channel 12 weatherwatcher during this storm period. More than 14 inches were recorded at numerous stations between West Palm Beach and Jupiter. Some residents from Seminole Colony, Waterview Mobile Home Park, and the Westgate areas had to be evacuated from their homes due to high waters. Westgate received an estimated $150,000 in flood damage. Damages of $90,000 were sustained by mobile homes, most of which were in Waterview Mobile Park. Single-family homes in several other locations were also flooded, especially the subdivisions of Lone Pine Estates and Gramercy Park. Parts of Dreher Park Zoo were flooded with water standing up to 14 inches deep.

Numerous power failures resulted from flooding and high winds. One man was electrocuted when he stepped on a downed powerline in Juno Beach.

This storm occurrence coincided with the autumnal astronomical high tides that normally occur during this time of the year. This compounded the adverse effects of the rough seas generated by the storm center. Serious beach erosion and coastal flooding occurred

from Palm Beach County northward along the coast. In Palm Beach County, the storm crumbled portions of the Juno Beach Pier and washed out sections (up to 50 feet) of State Road A1A along Ocean Boulevard. Water and sewer lines beneath A1A were severed causing major inconveniences for people living in this area. This forced beaches from Phipps Park to Boynton Beach to be closed for approximately 10 days. A 230 foot freighter with engine trouble crashed into the seawall in a residential area of the Town of Palm Beach. Seaspray Avenue in Palm Beach was covered with waist deep water.

Although this storm was not classified as a tropical storm or hurricane, it caused more damage than recent storms of these classifications. There are two reasons this unclassified storm caused such damage. First, as mentioned previously, it coincided with the annual autumnal high astronomical tides. Second, the total duration of the storm (48+ hours) caused an accumulative effect of storm surge and runoff that exceeded that of many hurricanes and tropical storms which typically pass in about 12 hours. Appendix B summarizes some of the widespread damages caused by this major, but unclassified, storm.

II. Rainfall Distribution

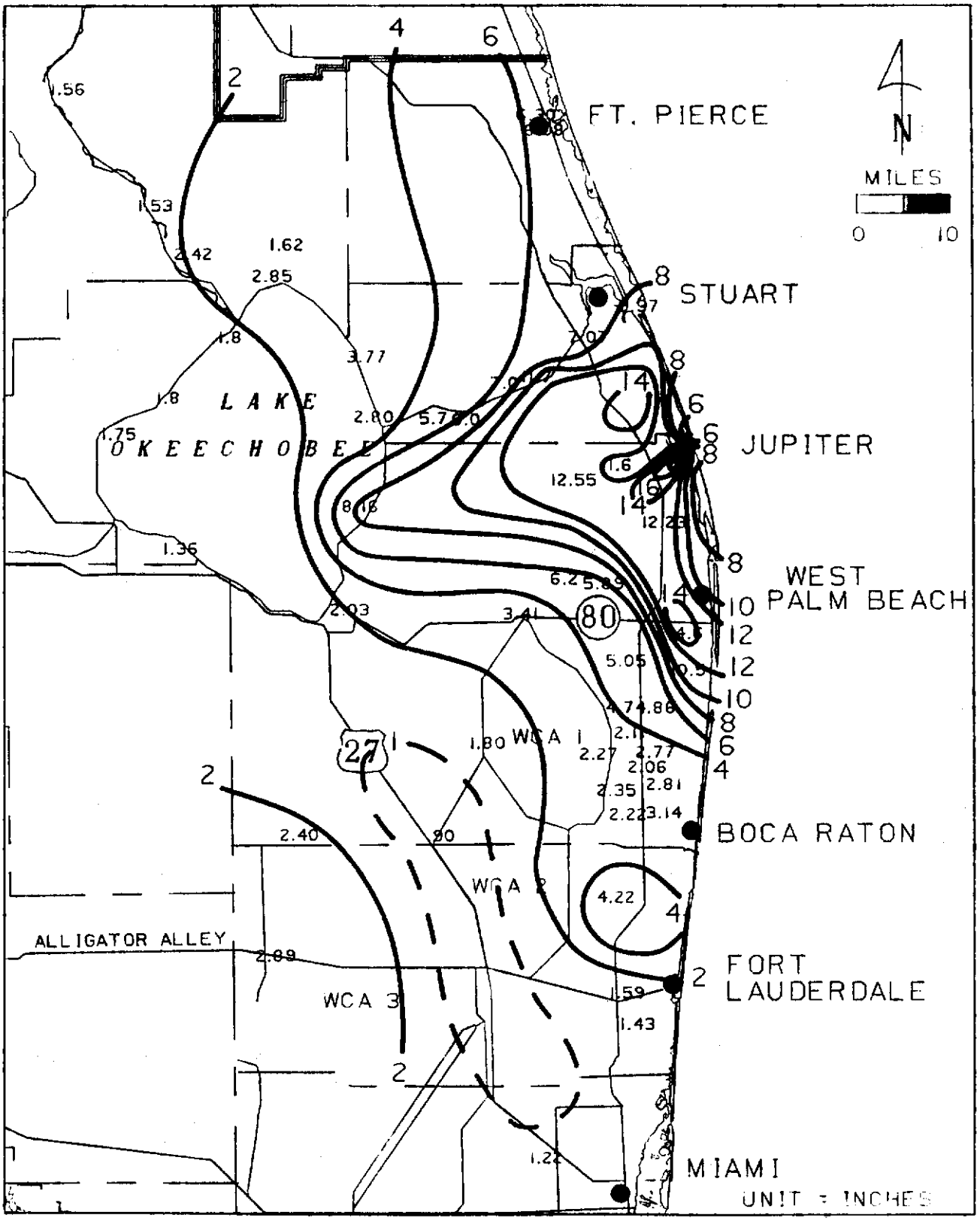
A cold front, which moved southeastward from the midwest, passed quickly through south Florida on November 20 causing generally very light rain throughout the District basins. Rainfall measurement at the West Palm Beach Field Station was 0.64 inch; however, most stations recorded less than one-tenth of an inch. The cold front became stationary in the Florida straits during Wednesday, creating conditions more favorable for widespread moderate showers as

increasing northeasterly winds brought a large amount of moisture into the eastern coastal regions. A weak low pressure center was developing on the frontal system and moved slowly northward to a position just off the coast of Broward-Palm Beach Counties during the morning of November 22, where it became nearly stationary and intensified. Heavy rains were measured in eastern Palm Beach, Martin, St. Lucie, and Indian River Counties.

The precipitation distribution from this low pressure center was typical for a slowly moving, intensifying storm with heaviest rainfall to the north side. The blocking high pressure center off the mid-Atlantic coast and the strong pressure gradient immediately north of the low pressure center made conditions more favorable for heavy rains along coastal regions. Drier air to the southwest of this storm produced less rain in Dade and Broward Counties. A series of national weather maps describing the meteorological events that occurred between November 19 and November 26 are presented in Appendix A.

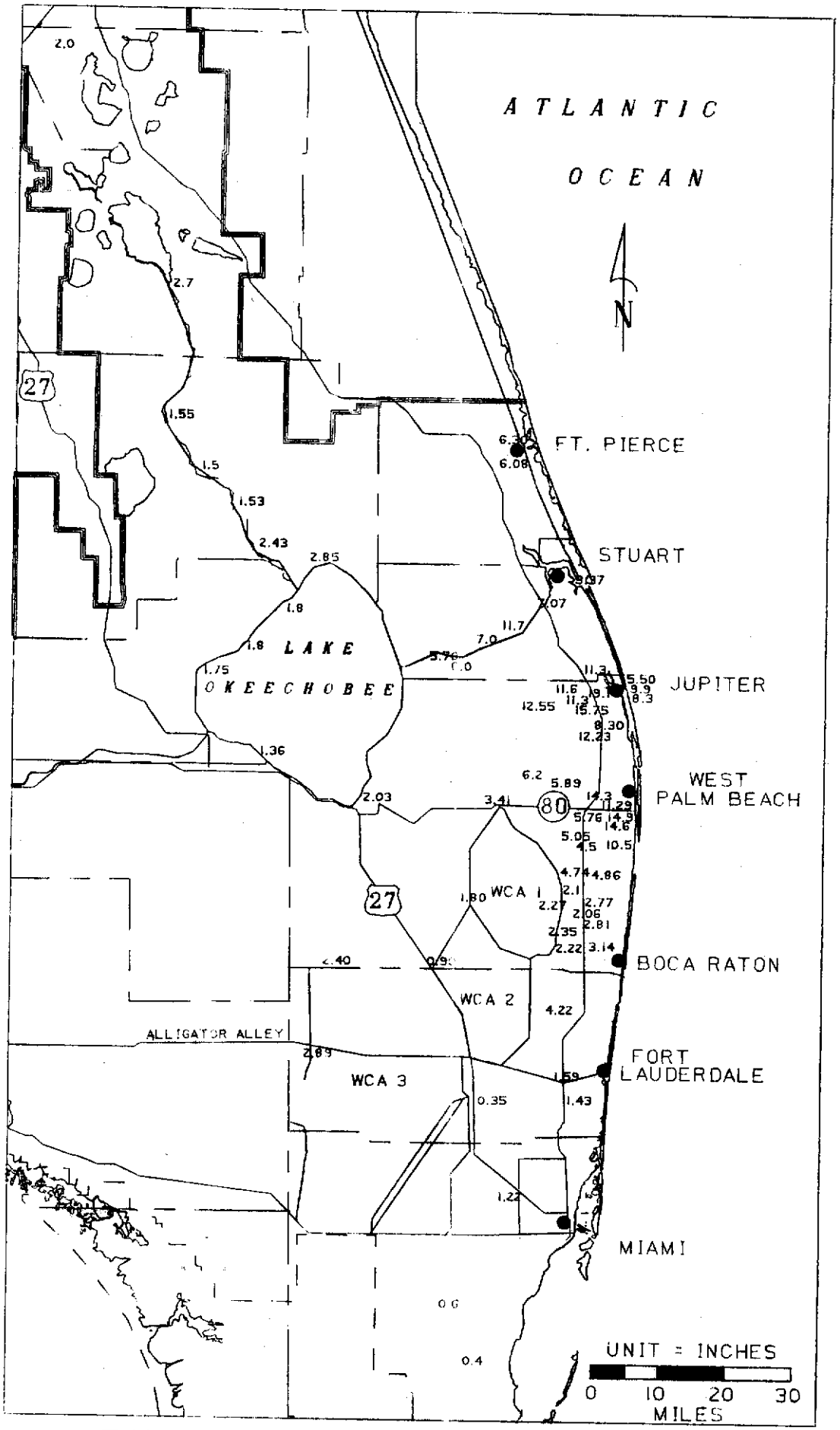
Figure 1 presents detailed rainfall measurements along the east coast of Florida, while Figure 2 presents measurements throughout the District. Table 1 lists the available daily rainfall values at various locations throughout the District.

Due to the storm's arrival during a holiday weekend, some measurements had to be accumulated over several days. Heaviest rainfalls were measured in a band 5 to 10 miles inland from the coast stretching from the City of Lake Worth to an area northwest of Jupiter. Rainfall amounts greater than 12 inches were common in this region with more than 19 inches being reported in one



ISOHYETAL MAP OF NOV. 21-26, 1984
STORM IN ST.LUCIE, MARTIN
PALM BEACH, BROWARD & DADE COUNTIES

FIG. 1



TOTAL RAINFALL RESULTING FROM
NOV. 21-26, 1984 STORM

FIG. 2

TABLE 1

DAILY RAINFALL VALUES AT VARIOUS LOCATIONS

Station Name	11/21	11/22	11/23	11/24	11/25	11/26	Total	Reading Time
Lower East Coast								
Greenacres City	0.45	X	X	X	X	5.31A	5.76	8 a.m.
Lake Worth Rd & E1	0.20	X	X	X	X	4.85A	5.05	8 a.m.
Boynton Rd & Military Tr	0.02	X	X	X	X	4.84A	4.86	8 a.m.
Boynton Rd & E2	0.02	X	X	X	X	4.72A	4.74	8 a.m.
Lateral 28 & Rangeline	0.01	X	X	X	X	2.10A	2.11	8 a.m.
Lateral 30 & LWDD Office	0.01	X	X	X	X	2.76A	2.77	8 a.m.
Delray Rd & E2	0.01	X	X	X	X	2.05A	2.06	8 a.m.
Lateral 32 & Rangeline	0.02	X	X	X	X	2.25A	2.27	8 a.m.
Boca Rd & Rangeline	0.04	X	X	X	X	2.18A	2.22	8 a.m.
Boca Rd & Powerline	0.01	X	X	X	X	3.13A	3.14	8 a.m.
Military Tr & Lateral 38	0.05	X	X	X	X	2.76A	2.81	8 a.m.
Rangeline & Lateral 39	0.15	X	X	X	X	2.20A	2.35	8 a.m.
Pratt & Whitney	1.80	7.60	2.70	0.45	0.00	0.00	12.55	Midnight
Jupiter Fire Station #3	3.38	2.91	3.58	0.24	0.00	0.00	10.32	Midnight
Margate	0.15	2.00	0.95	1.10	0.02	0.00	4.22	9 a.m.
Ft. Lauderdale	0.80	0.04	0.59	0.16	0.00	0.00	1.59	5 p.m.
Palm Beach Int'l Airport	1.18	7.41	2.30	0.40	0.00	0.00	11.29	Midnight
W.P.B. Field Station	2.22	9.05	2.64	0.38	0.00	0.00	14.52	Midnight
S-5A	0.05	1.84	1.30	0.25	0.00	0.00	3.46	Midnight
S-36	2.15	0.19	0.79	0.04	0.00	0.00	3.17	Midnight
Miami Locks	0.01	1.43	0.32	0.00	0.00	0.00	1.76	Midnight
419 Sequoia Dr (W.P.B.)	0.48	6.40	2.20	3.25	0.15	X	12.48	8 a.m.
364 LaMancha Ave (Royal Palm Beach)	0.05	0.84	1.80	2.90	0.30	0.00	5.84	7 a.m.
4444 Elroy Rd (Lake Worth)	0.52	3.50	2.25	3.83	0.05	0.01	10.16	9 a.m.
178 Drawdy Rd (W.P.B.)	X	4.15A	2.27	X	0.81A	X	7.23	6 p.m.
4434 Fuscia Ci. S. (P.B. Gardens)	1.39	4.54	5.72	0.56	0.02	X	12.23	6 p.m.
Int. Okee. & Haverhill (W.P.B.)	5.05	5.62	3.24	0.40	0.00	0.00	14.31	Midnight
300 Block, A1A Jupiter	3.50	4.50	2.18	T	0.00	0.00	9.88	Midnight
Nathan Hale Rd (W.P.B.)	1.55	8.75	4.08	0.60	0.00	0.00	14.95	Midnight
Indian Trail Rd (Jupiter)	1.75	7.35	2.35	0.15	0.00	0.00	11.60	Midnight

Table 1 - continued

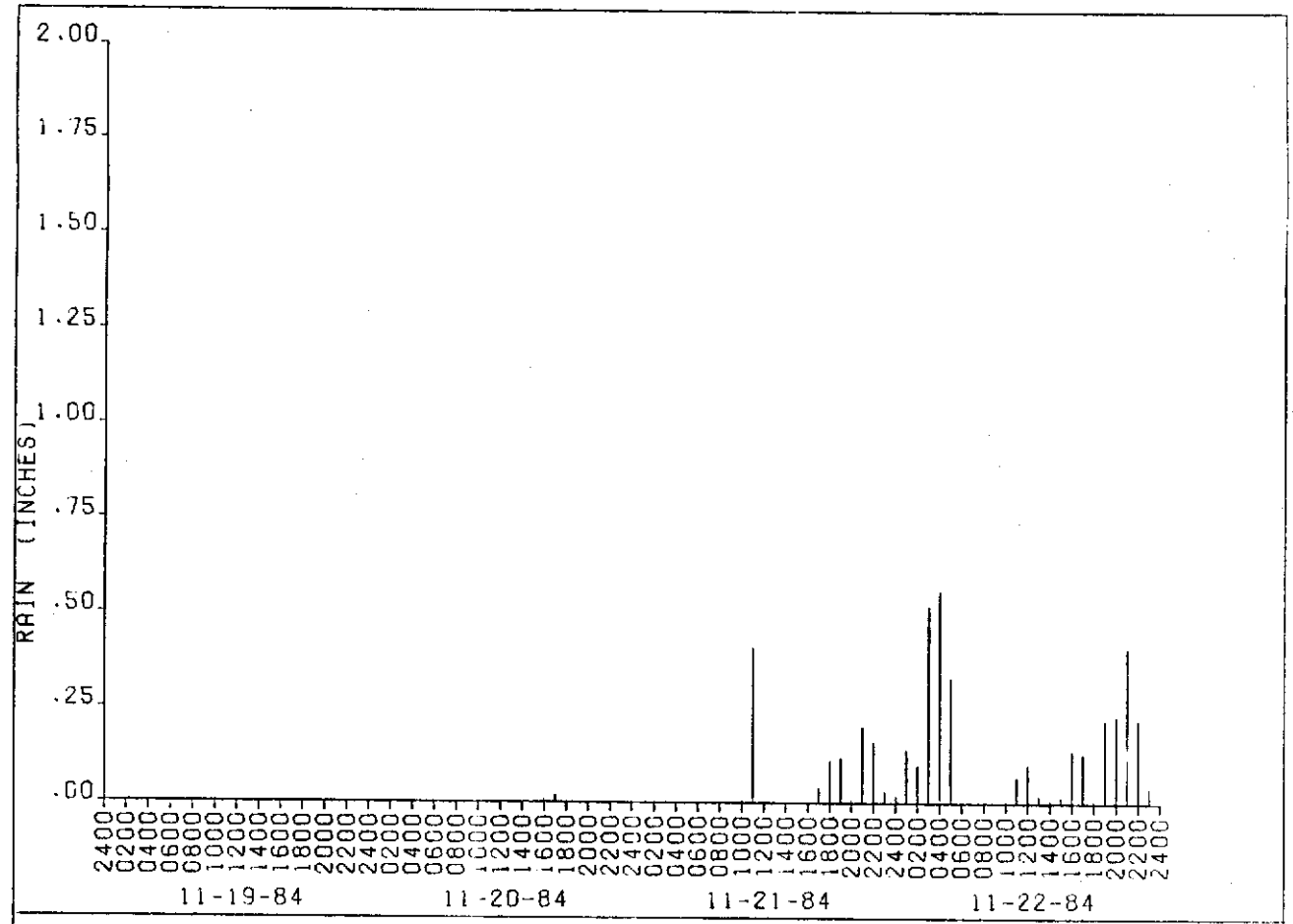
Station Name	11/21	11/22	11/23	11/24	11/25	11/26	Total	Reading Time
165th Place (Jupiter)	1.55	4.65	5.50	1.00	T	0.00	12.70	Midnight
Cree St. (Jupiter)	5.26	8.23	5.19	0.42	0.00	0.00	19.10	Midnight
E. of C-18 nr. Donald Ross Rd	X	X	X	X	X	15.75A	15.75	p.m.
W. of C-18 nr. Donald Ross Rd	X	X	X	X	X	X	11.30	p.m.
Jonathan's Landing (Jupiter)	0.22	4.00	2.25	1.65	0.10	0.00	8.22	7 a.m.
Juno Fire Station	3.50	2.80	X	1.00A	X	1.00A	8.30	a.m.
Tequesta Fire Station	3.12	4.51	2.45	1.11	0.09	0.00	11.28	a.m.
Caulkins Citrus Co.	X	X	X	X	X	X	11.70	a.m.
Caulkins Citrus Venture I	X	X	X	X	X	X	6.00	a.m.
Caulkins Citrus Venture II	X	X	X	X	X	X	5.70	a.m.
Caulkins Indiantown Grove	X	X	X	X	X	X	7.00	a.m.
Upper East Coast								
Fort Pierce	1.03A	X	X	X	X	5.05A	6.08	8:30 a.m.
Stuart	2.12	2.00	4.21	1.02	0.02	0.00	9.37	4:30 p.m.
Vero Beach Airport	4.33	1.77	0.95	0.54	0.00	0.00	7.59	Midnight
S-80 St. Lucie Lock	0.03	2.91	1.85	2.27	0.01	0.00	7.07	8:00 a.m.
Port Mayaca	0.05	0.15	1.15	1.45	T	0.00	2.80	8:00 a.m.
Mayflower Grove	0.15	3.15	2.00	3.35	0.00	0.00	8.65	a.m.
Everglades Agricultural Area								
HGS-2	0.03	0.27	0.83	0.06	0.00	0.00	1.19	8:00 a.m.
Belle Glade	0.24	1.34	0.45	0.00	0.00	0.00	2.03	8:00 a.m.
S-5A	0.05	1.84	1.30	0.25	0.00	0.00	3.46	Midnight
South Bay	0.00	2.23	0.48	0.00	0.00	0.00	2.71	Midnight
Lake Okeechobee								
Canal Point	4.00	0.61	2.00	1.55	0.00	0.00	8.16	8:00 a.m.
HGS-2	0.03	0.27	0.83	0.06	0.00	0.00	1.19	8:00 a.m.

Table 1 - continued

Station Name	11/21	11/22	11/23	11/24	11/25	11/26	Total	Reading Time
Kissimmee River Basin								
S-65D	0.07	X	X	X	X	1.46A	1.53	Midnight
S-65B	0.10	X	X	X	X	1.45A	1.55	Midnight
S-65E	0.07	X	X	X	X	2.45	2.52	7 a.m.
Lower West Coast								
S-77	0.07	1.70	1.03	0.08	0.00	0.00	2.88	8 a.m.
S-78	0.00	1.15	0.65	0.00	0.00	0.00	1.80	8 a.m.
S-79	0.00	0.62	0.22	0.00	0.00	0.00	0.84	8 a.m.

case for the period from November 20 through November 24. Between Boynton Beach and Fort Lauderdale, 5-day rainfall ranged from 2 to 4 inches. South of Fort Lauderdale less than 2 inches of rainfall were observed. North of Stuart, rainfall amounts were generally around 6 inches near the coast, and decreased inland to less than 2 inches. The inland extent of heavy rainfall, measured at the eastern bank of Lake Okeechobee at Canal Point, was 8 inches. Overall, the lake received about 2 inches of rainfall, while the Kissimmee River basin received between 1 and 2 inches, and the Water Conservation Areas received between 0.3 to 3 inches of rainfall. The highest totals in the Water Conservation Areas occurred in the northeast portion of Water Conservation Area 1, while the minimum occurred near the S-9 pumping station where 0.35 inch of rainfall was recorded.

The hourly rainfall distribution at five recording stations is shown in Figure 3. The recorders are located at St. Lucie Lock, Jupiter Fire Station West, West Palm Beach Field Station, Fort Pierce, and S-5A. The most intense rainfall was recorded at the West Palm Beach Field Station between 2300 hours, November 21, and 0500 hours, November 22, with an average rate of more than 1 inch per hour. At the field station, the maximum intensity was 1.99 inches per hour recorded between midnight and 0100 hours November 22. Lighter rains continued throughout the day until 1800 hours, November 22, when moderately heavy rain dumped an additional 2.21 inches of water on the area. The most intense rainfall during November 22 fell between 2000 and 2100 hours when 0.92 inch was recorded. Moderate showers continued throughout the following day. A total of 6.6 inches of rainfall in 6 hours has a one in ten year recurrence frequency



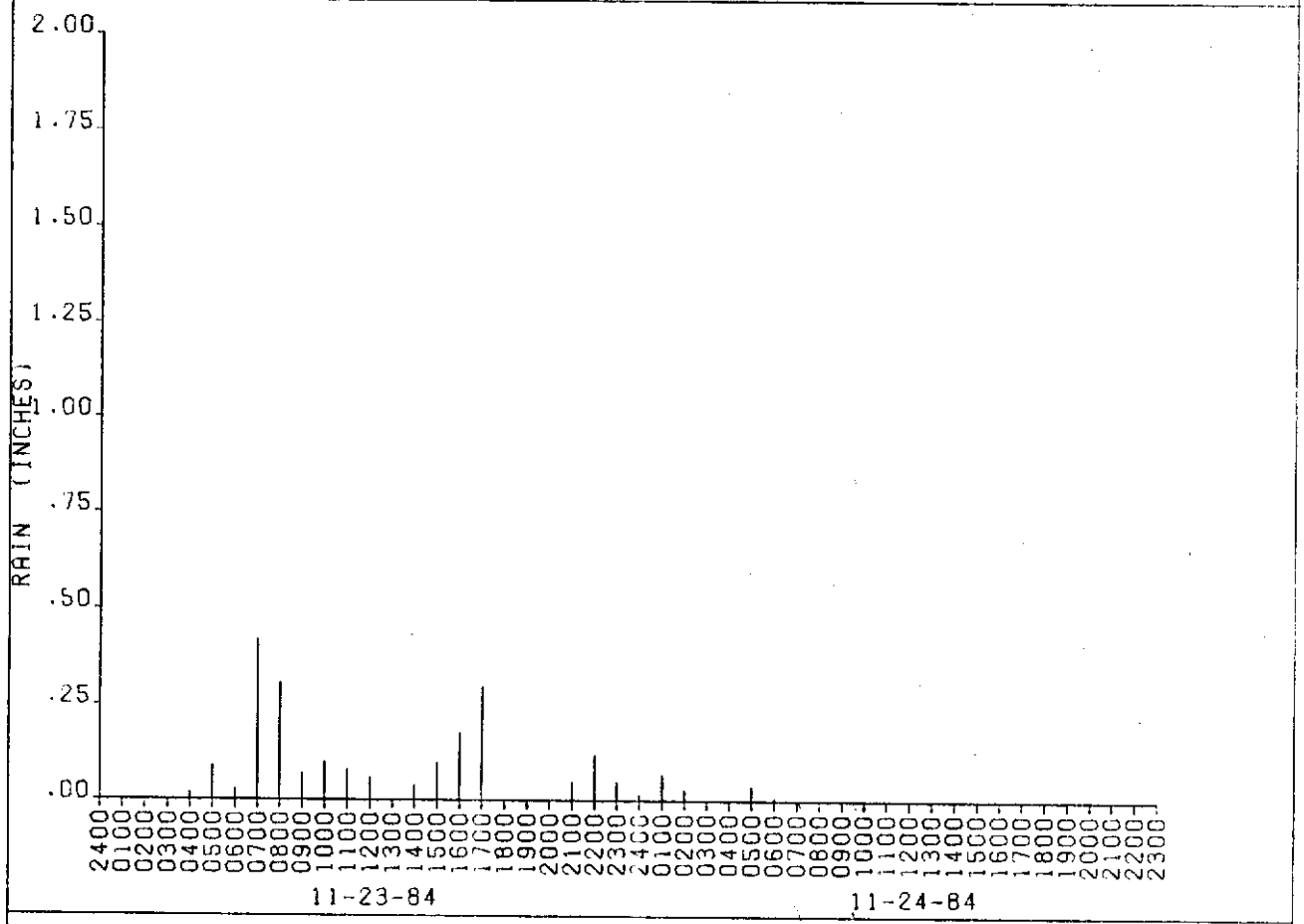
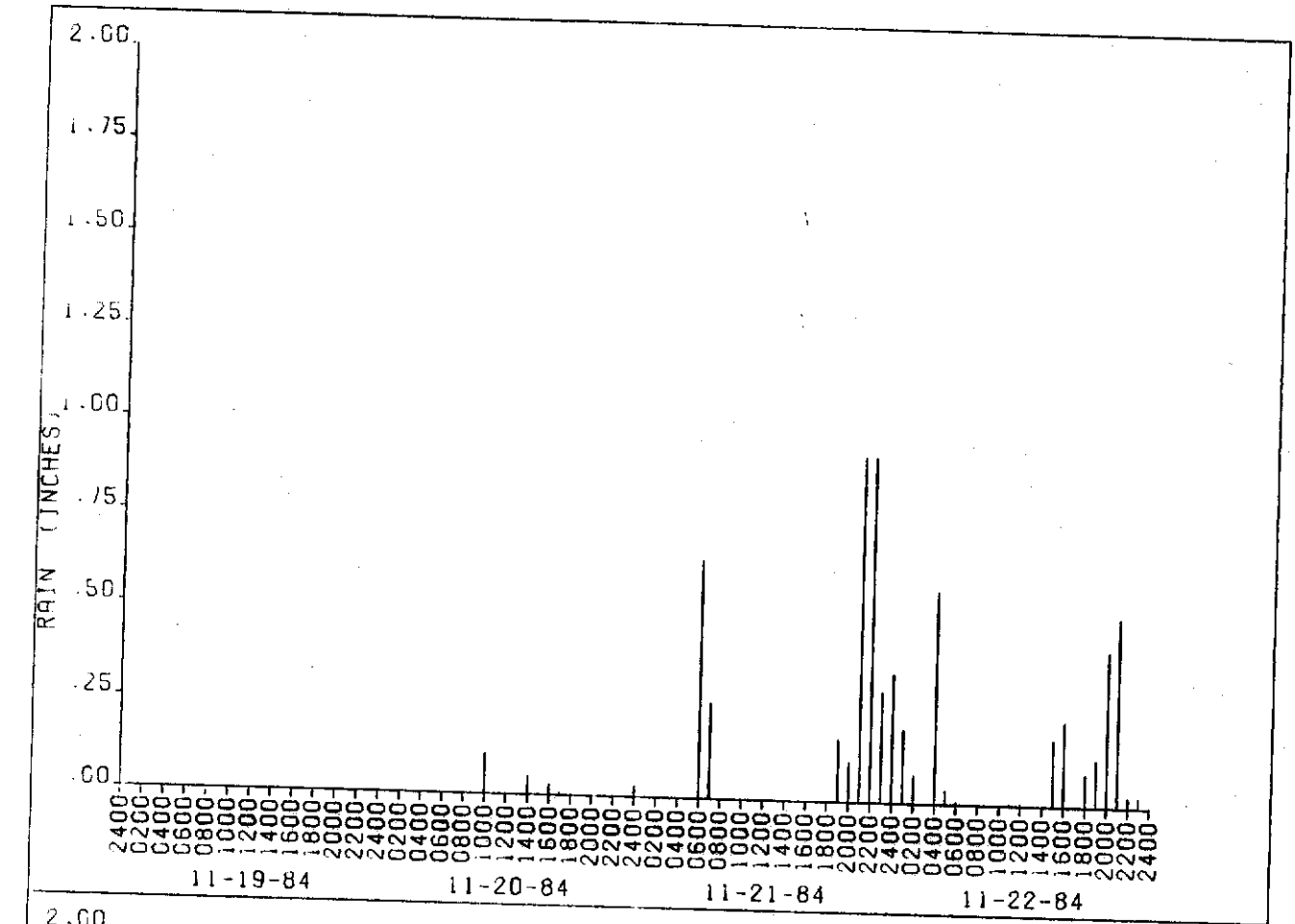


FIG. 3A HOURLY RAINFALL AT ST. LUCIE LOCK



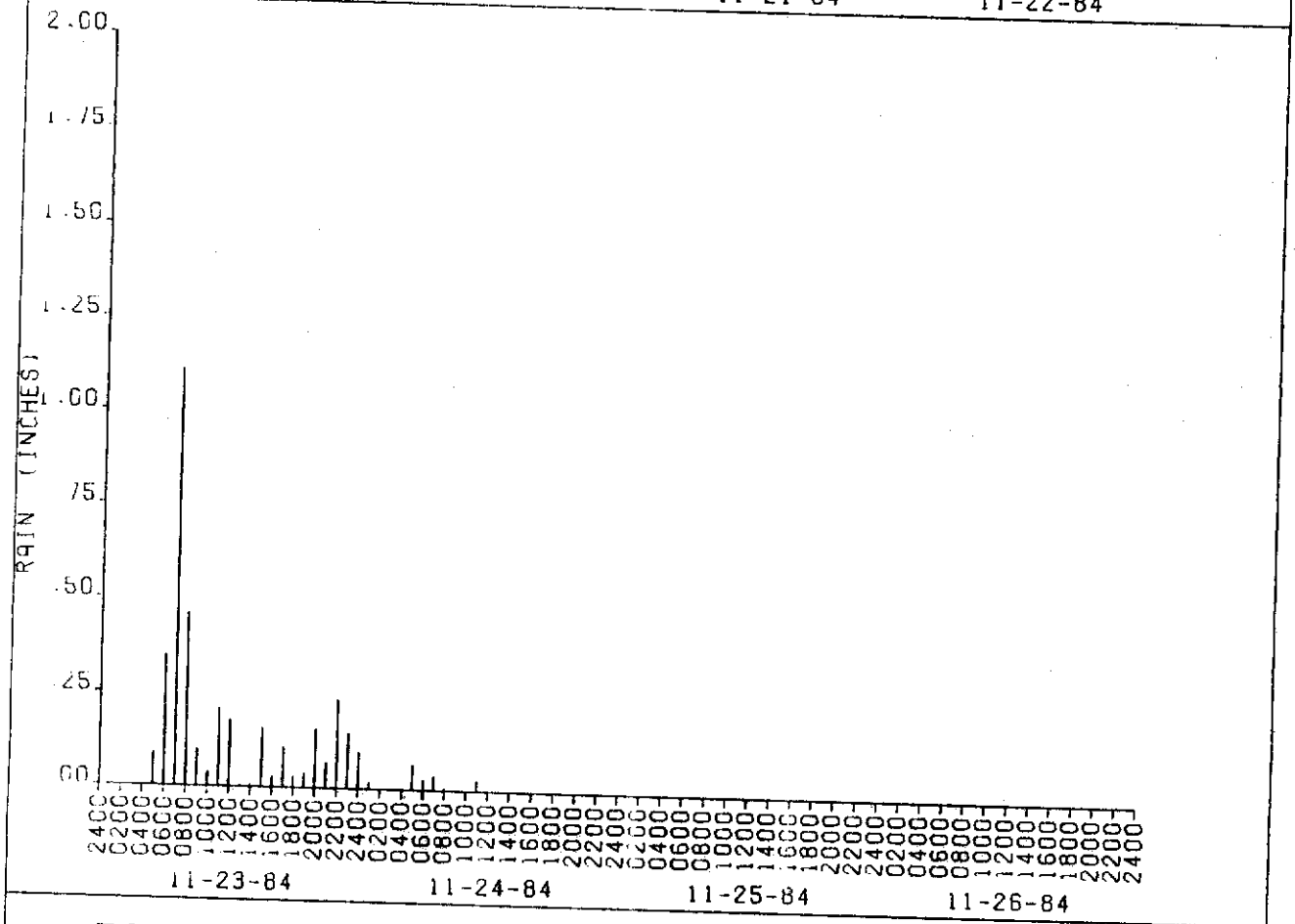
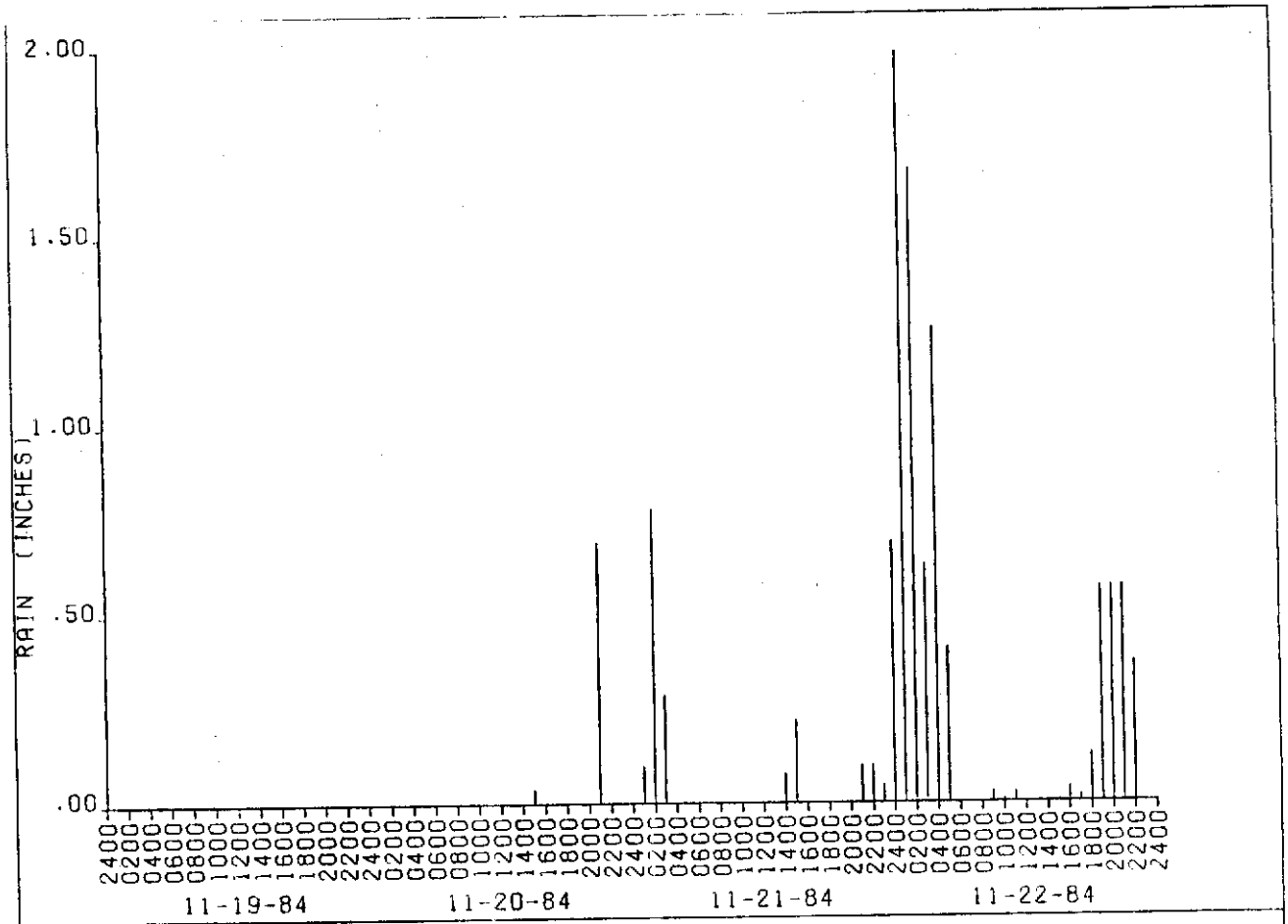


FIG. 3B HOURLY RAINFALL AT JUPITER FIRE STA.



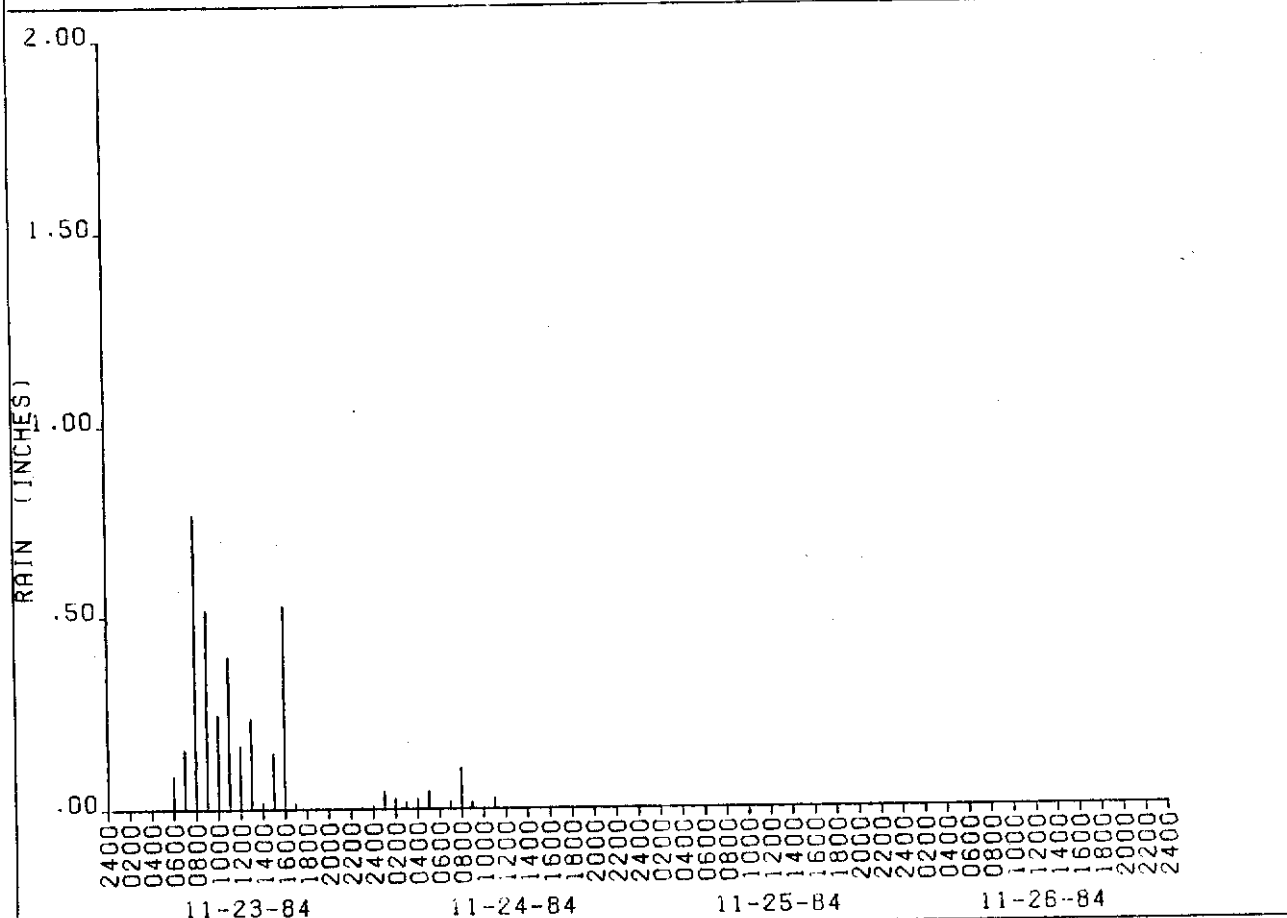
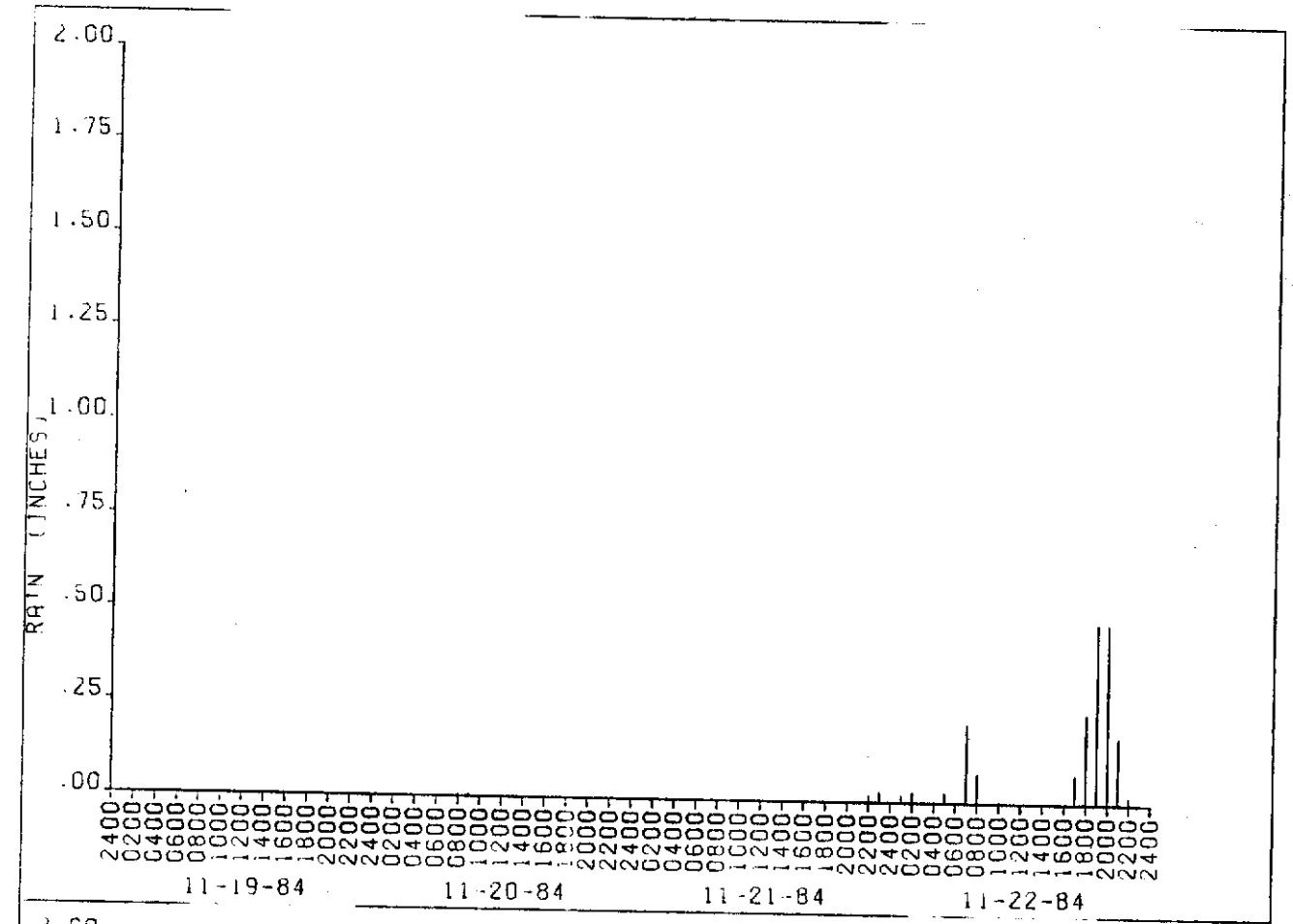


FIG. 3C HOURLY RAINFALL AT W. PALM BCH. F/S



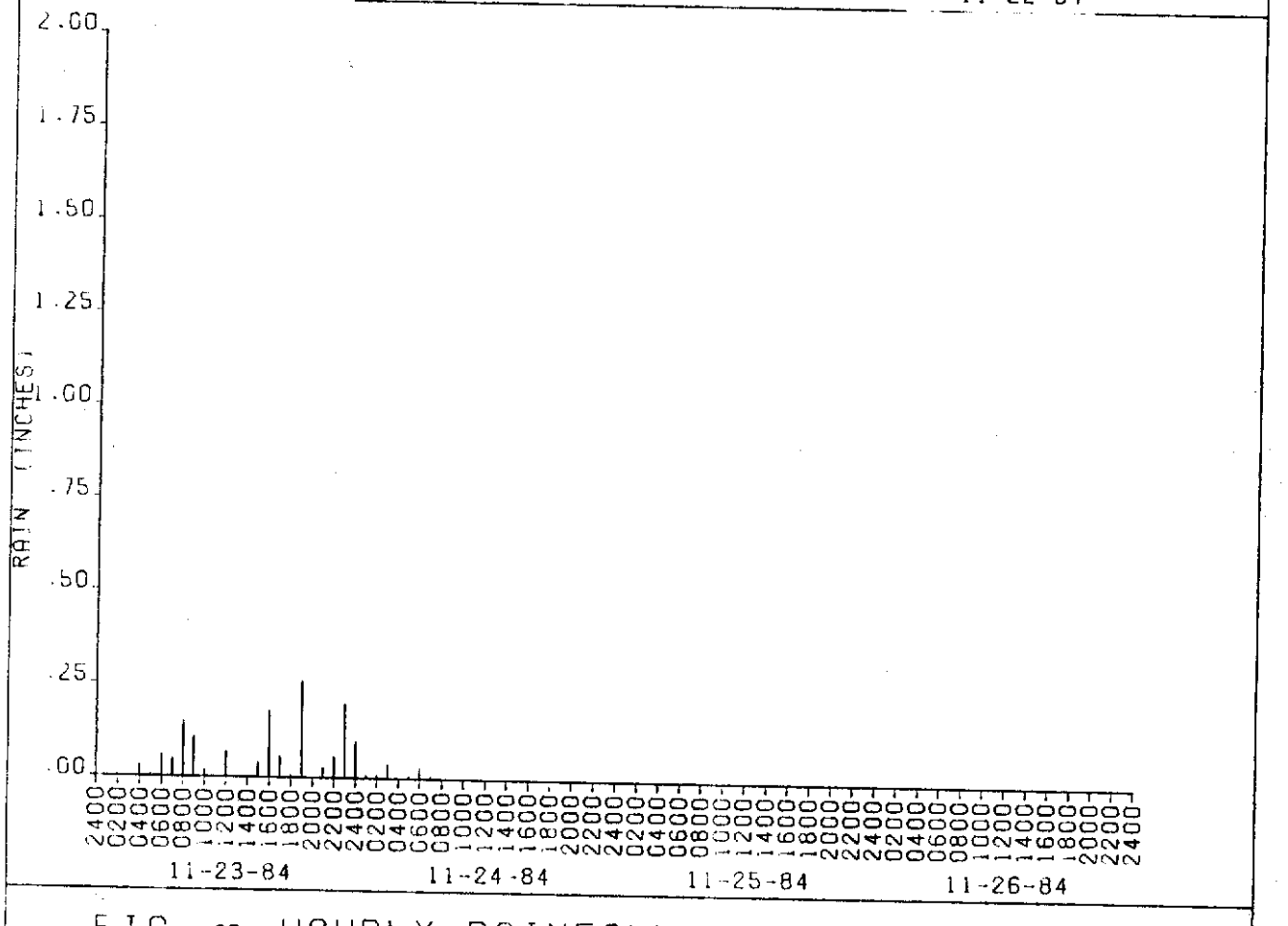
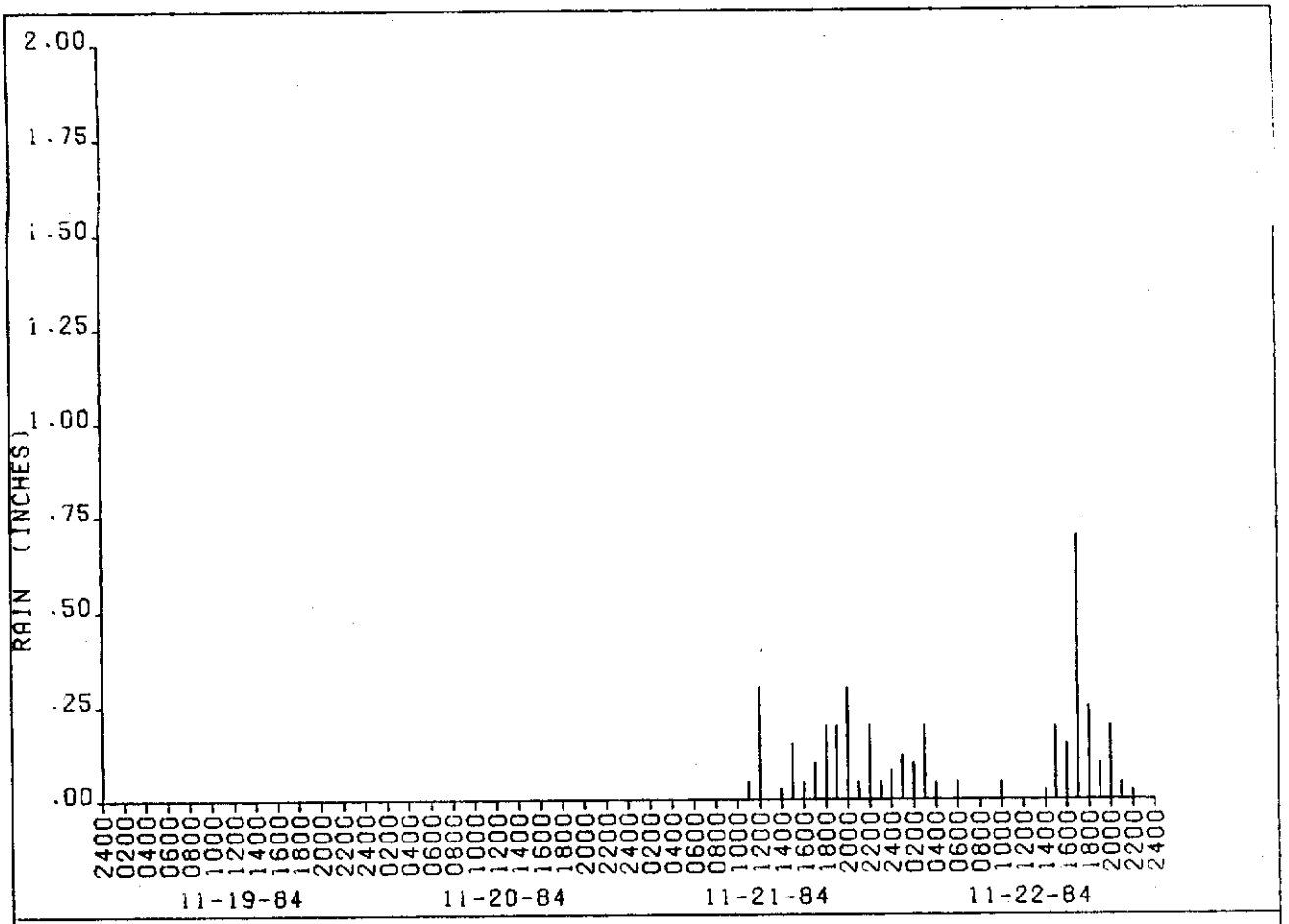


FIG. 3D HOURLY RAINFALL AT S-5A PUMP STATION



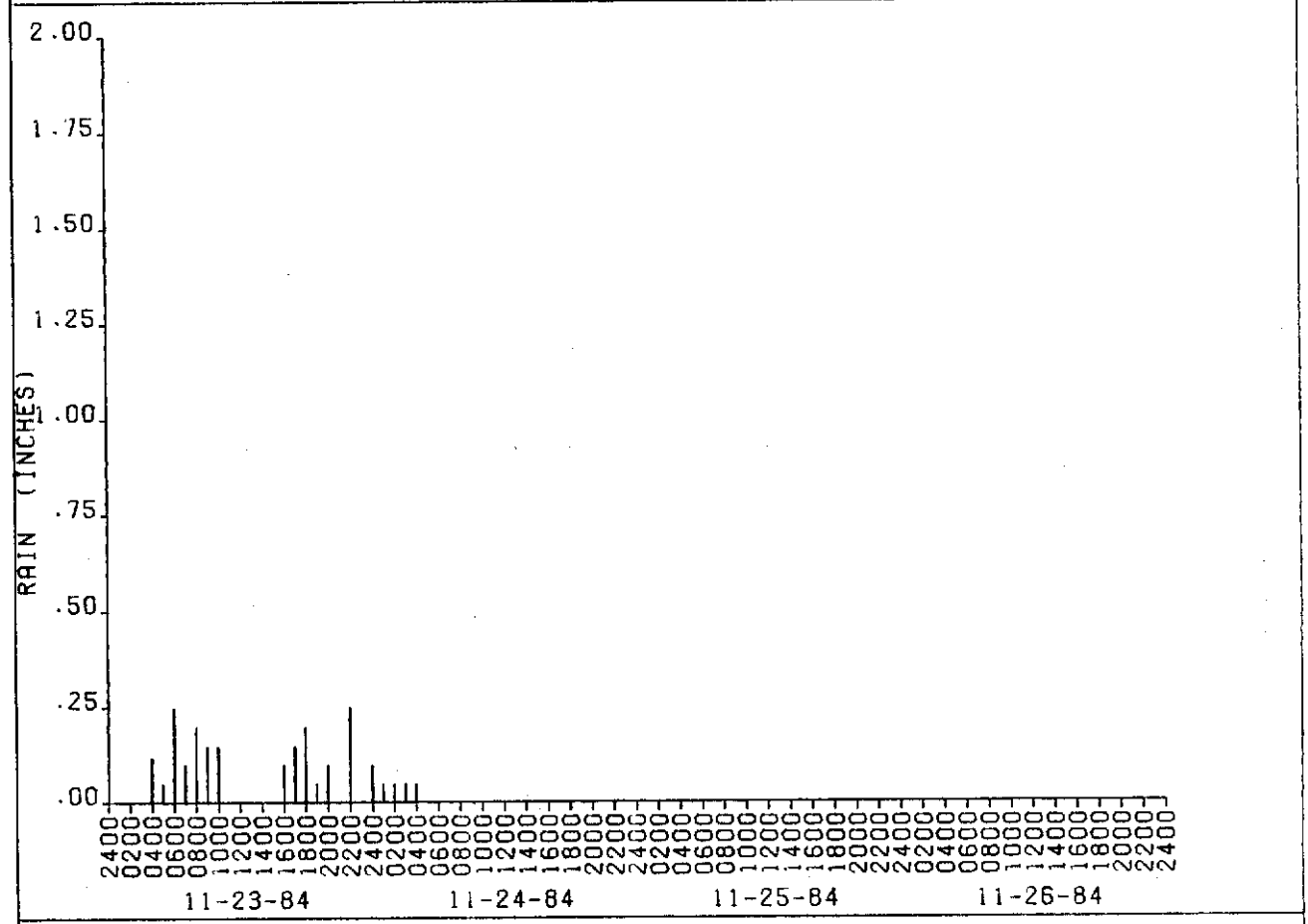


FIG. 3E HOURLY RAINFALL AT FT. PIERCE F/S

(Weather Bureau Technical Report #40). A total rainfall of 9 inches on November 22, recorded at the West Palm Beach Field Station, is approximately a once in ten year frequency. The three and five day rainfall totals were in the order of once in 25 year events ("Frequency Analysis of Rainfall Maximums for Central and Southern Florida" District Technical Publication 81-3). The region west of Jupiter, which received between 12 and 14 inches of rainfall during the five day, period had an overall return frequency of about once in 25 years. However, the highest rainfall of 19 inches, west of Jupiter, had a return frequency slightly less than once in one hundred years. The Dyer landfill area had about 12 inches of rainfall which has a return frequency of about once in 15 to 20 years. The West Palm Beach Field Station recorded the highest intensity hourly rainfalls.

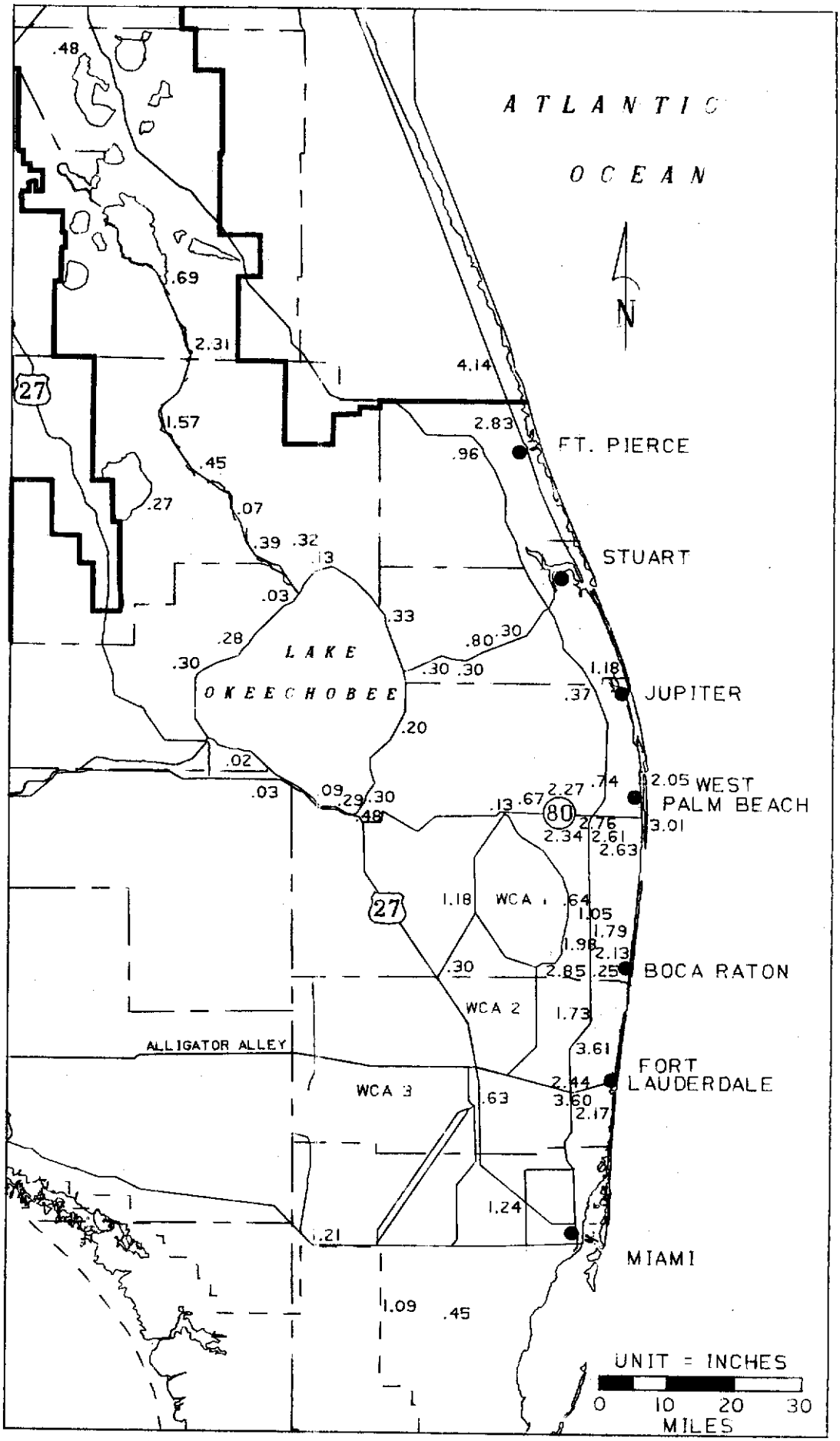
III. Antecedent Conditions

A. Rainfall

In the two weeks prior to this storm, there was very little or no rainfall throughout the District. November 5 was the last report of substantial rainfall within the District (see Fig. 4). October 1984 was also a very dry month with only about 2 inches of rainfall reported along the coastal regions of Palm Beach, Martin, and St. Lucie Counties. This was about 30% of the normal October rainfall. Other parts of the District were much drier. Figure 5 illustrates an isohyetal map of rainfall for the month of October.

B. Canal Stages

Table 2 lists water level elevations at crucial locations at mid-day Tuesday, November 20, before the arrival of the



ANTECEDENT RAINFALL FOR PERIOD NOVEMBER 1-20, 1984.

FIG. 4

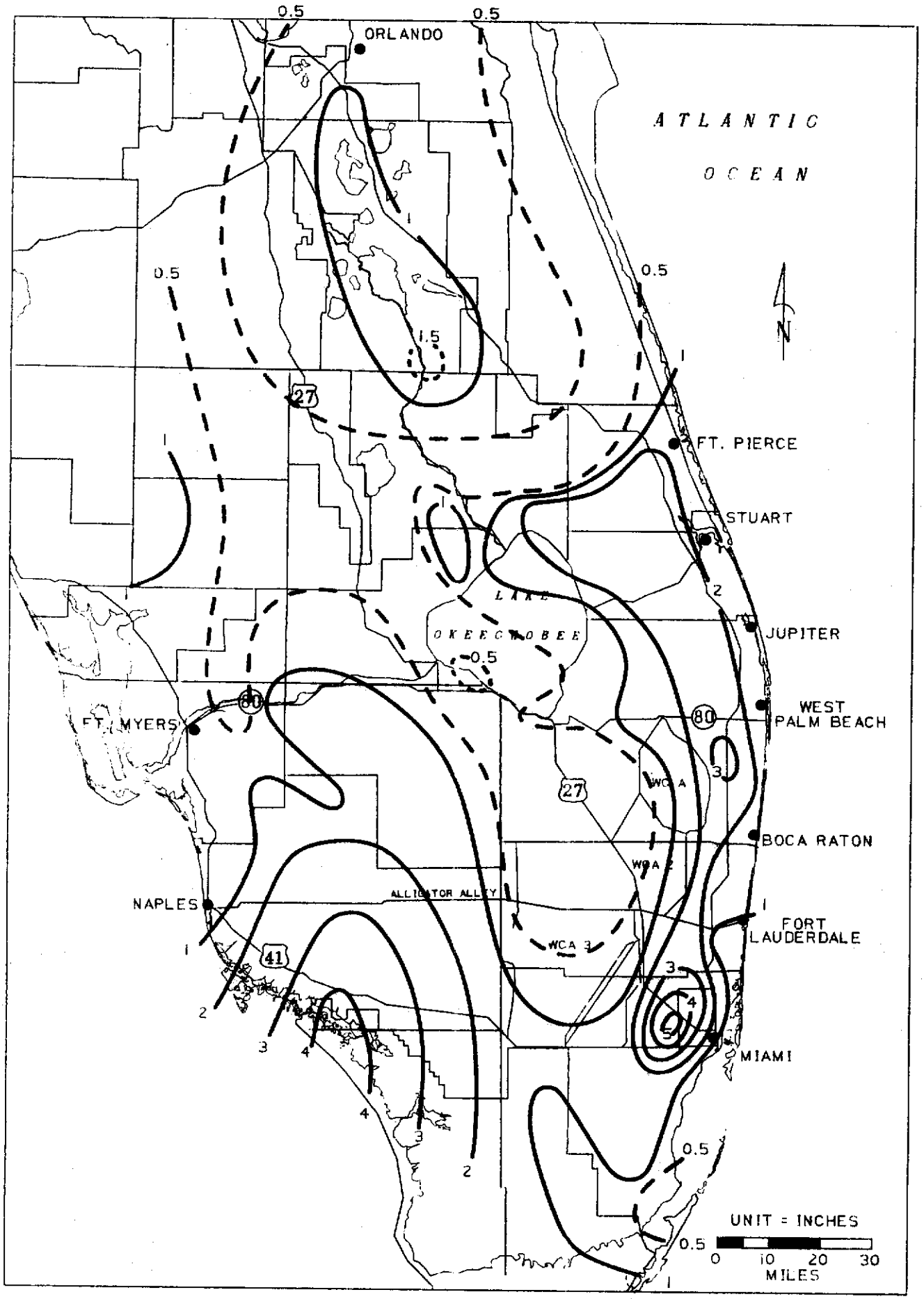


FIG. 5 RAINFALL - OCTOBER, 1984

storm. Stages at major structures were within their optimal range.

TABLE 2

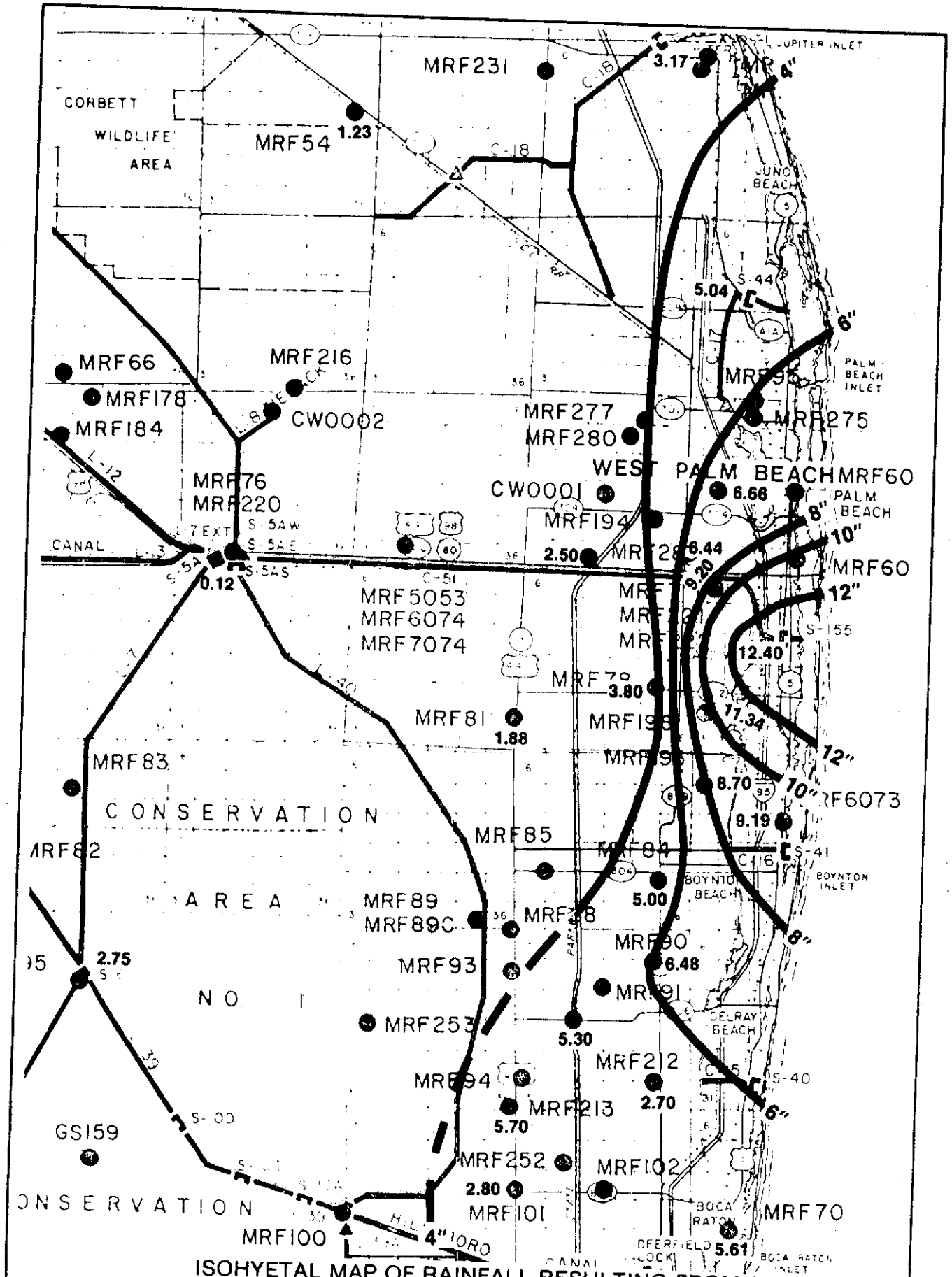
WATER LEVELS ON NOVEMBER 20, 1984
AS COMPARED TO THEIR OPTIMUM STAGES

Structure	Nov. 20, 1984 Stage (Hour 1200) ft NGVD	Dry Season Optimum Range Stage - ft NGVD
S-41	8.50	7.90- 8.80
S-44	7.20	6.80- 7.30
S-46	14.60	14.50-15.00
S-155	8.35	8.00- 8.50
W.P.B. Field Station	8.45	8.00- 8.50

IV. Rainfall Comparison

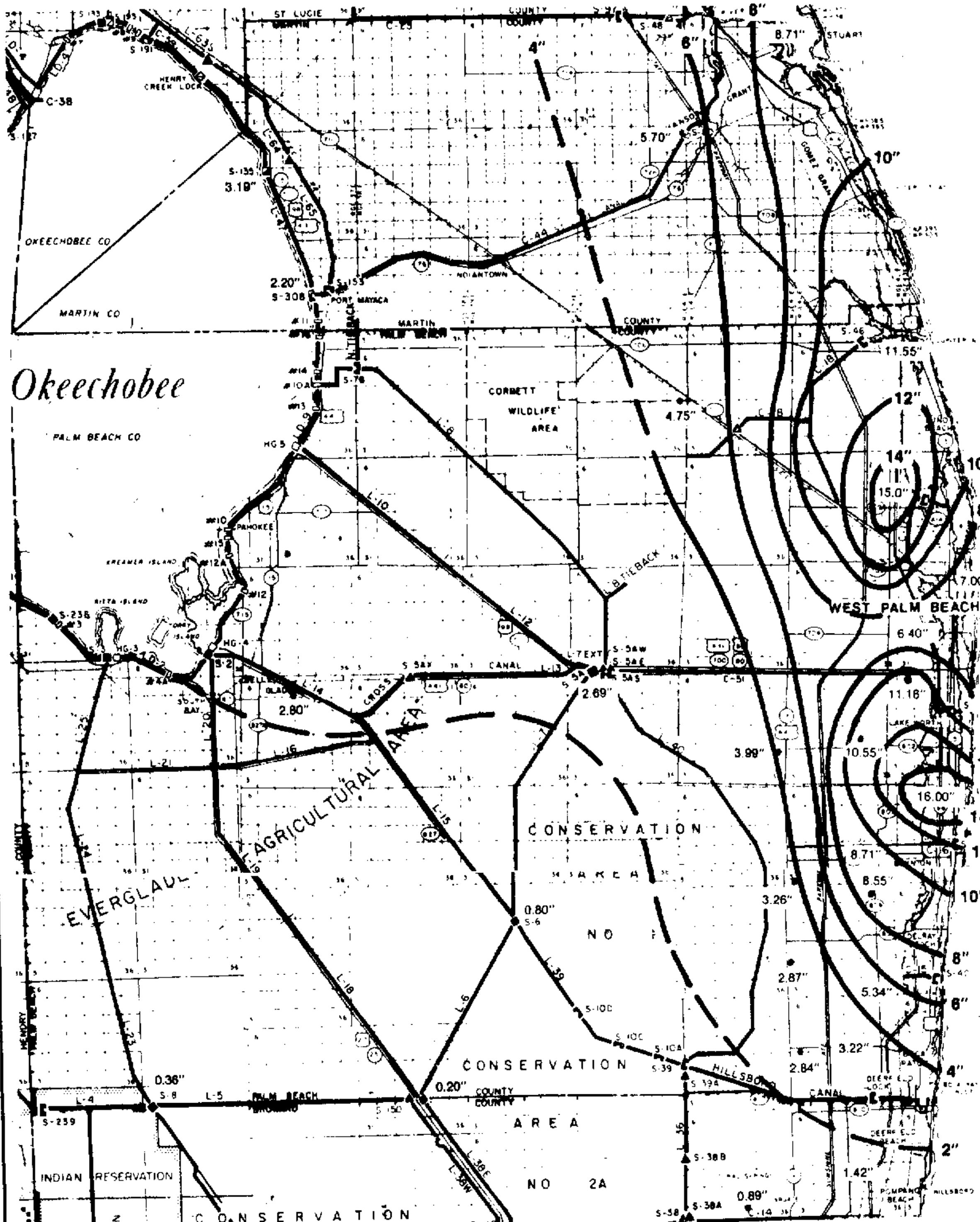
Maximum measured rainfall amounts were greater than those that occurred during the March 28-29, 1982 and April 23-26, 1982 storms in Palm Beach County. Isohyetal maps of these two past events are shown in Figure 6 and Figure 7. The March and April storms were confined to the coastal area while this most recent storm produced larger amounts of rainfall inland as far as the eastern shore of Lake Okeechobee. This storm produced more damage because more intensive rainfall fell on flood prone areas like Westgate and the Waterview Mobile Parks These areas have been subject to frequent flooding by moderate storms. In the March and April 1982 storms they received about 8 inches of rainfall, while in this recent storm they received up to 13 inches of rain. Much of the rain fell in very heavy showers on November 22 before sunrise and again that evening.

Large rainfall amounts west of Jupiter were also common during this storm; however, flooding may have been minimized due to the very



ISOHYETAL MAP OF RAINFALL RESULTING FROM APRIL 23-26, 1982 RAINSTORM IN EASTERN PALM BEACH COUNTY

FIG. 6



ISOHYETAL MAP OF RAINFALL RESULTING FROM MARCH 28-29, 1982 RAINSTORM

FIG. 7

dry October and first part of November that preceded this storm which kept the soil unsaturated.

V. Flooded Areas - Waterview Mobile Park (Figure 13)

The following high water marks were surveyed on November 28, 1984 as compared to the high water marks available from the March 28-29, 1982, April 23-26, 1982, and September 17-18, 1960 rainstorms.

TABLE 3

COMPARISON OF HIGH WATER MARKS FOR SELECTED STORMS

Location	Sept 17-18 1960 (ft MSL)	Mar 28-29 1982 (ft MSL)	Apr 23-26 1982 (ft MSL	Nov 22-26 1984 (ft MSL
Congress Av & L-2 LWDD	-	-	-	12.72
Waterview Mobile Park	±15.00*	13.50	11.22	-
Florida Mango & L-2 LWDD	-	-	-	12.49
Bridge at Australian Av crossing Stub Canal	13.30	12.71	11.58	12.16
Bridge at Belevedere Rd crossing Stub Canal	13.30	12.13	-	11.70
Stub Canal @ Airport	-	11.80	-	11.41
Stub Canal @ Southern Bl	-	-	-	11.29
WPB Canal @ Summit Bl	-	11.03	10.23	8.8-9.3
WPB Canal @ Field Station	-	11.66	10.58	9.3
WPB Canal @ S-155 (P.B. Lock)	10.15	10.68	9.88	8.49

*Estimate based on Congress Avenue peak of 16.20 ft msl.

The flood stage in Waterview Mobile Park probably was higher than the peak stage during the April 23-26, 1982 rainstorm; however, it was much less than previous storms as shown in Table 3. It should

be noted that the water levels in the West Palm Beach Canal (C-51) were much lower than in previous storms. This was due to the fact that the manually operated Palm Beach lock has been replaced by a more effective and efficient automatic control spillway structure (S-155). It is also important to note that the water level at the structure at the upstream side (north side) of Southern Boulevard was at 11.29 ft msl, and the West Palm Beach Canal was at 8.8 to 9.3 ft msl during the peak hours. This was a head loss of almost 2 feet in a reach of approximately three-quarters of a mile. A preliminary estimation based on available cross sections in this reach, and the high water marks measured during the storm, indicated that there was approximately 1400 cfs of discharge in this reach resulting from this gradient. The flow through the Belvedere Road bridge crossing of the Stub Canal was estimated at ±850 cfs and approximately 350 cfs of flow through the bridge at Australian Avenue crossing the Stub Canal. The Stub Canal was designed for 588 cfs which consisted of 250 cfs from Clear Lake and 338 cfs from a 5.2 square mile area to the west. The following factors may have contributed to the excessive runoff.

A. Rainfall Amount

The following table compares the estimated rainfall over the Stub Canal Basin.

Events	Rainfall - Inches
Sept. 17-18, 1960	± 8.8
March 28-29, 1982	± 8.0
April 23-26, 1982	± 8.0
Nov. 22-26, 1984	±13.0

This Thanksgiving storm produced approximately 5 more inches of rainfall over previous storms.

B. New Developments in the Basin

The rapid development of the industrial park located to the east and southwest of Waterview Mobile Park, and the Hilton Inn Hotel and Restaurant complex located east and southeast of the Palm Beach International Airport, have substantially reduced the available storage for flood water and rapidly increased the rate and volume of runoff from the basin.

C. The Waterview Mobile Park is located on a relatively low land area. The ground elevation at the southwest corner of the park, on a catch basin, is at 9.76 ft msl, and the center line of Manor Street at 1616 Manor is at 10.90 msl. In general, the ground elevation of the mobile park area is below 12.5 ft msl, while the surrounding areas were developed above an elevation of 15.0 ft msl. Therefore, the mobile park receives runoff from the surrounding area which is a raised and paved industrial area.

Under the present West Palm Beach Canal cross-sections and the new automatic gated spillway structure S-155, the 30-year design stage at Summit Boulevard will be ±12.80 ft msl, and the 10-year stage could approximate 12.20 ft msl. Therefore, the Waterview Mobile Park will continue to have flooding problems as previously discussed in the report of the rainstorm of April 23-26, 1982.

As mentioned previously in this report, there was a head drop of 2 feet created in the downstream reach of the Stub Canal between Southern Boulevard and the West Palm Beach Canal. The latest survey indicated there were some shoals in this reach.

Some backwater runs based on the latest cross-section data surveyed on November 28, 1984, indicated that a head loss of ±0.15 ft may have resulted due to these shoals. Therefore, excessive runoff generated from the basin was attenuated by the limitation of the canal capacity in this reach which is 588 cfs.

In view of the possible adverse impact to the existing C-51 basin, it is not feasible to improve this reach of channel cross-section. Instead, it may be more feasible to consider a small pumping station and a flap gate control culvert to relieve the Waterview Mobile Park from frequent flooding. This would require a levee to protect the park area. Drainage would be to Lateral Canal #2 (L-2) of the Lake Worth Drainage District. The normal stage in L-2 is approximately 8.5 ft msl. The gated culvert should maintain a normal stage inside of the park of less than 9.0 msl. The pump should start up automatically at a stage of 9.5' msl and shut off at a stage of 9.0 ft msl.

OPERATION OF THE SYSTEM

There were no problems in the operation of the District facilities as will be discussed in this section.

A. S-155 - West Palm Beach Canal

The structure is located on C-51 (West Palm Beach Canal) east of U. S. Highway 1. This structure is a reinforced concrete, gated spillway with discharge controlled by three cable operated, vertical lift gates. The operation of the gates is automatically controlled.

The headwater stage was between 8.0 to 8.5 ft above mean sea level. After the storm started, the stage was lowered to 7.0 ft msl to facilitate the inflow from the West Palm Beach Canal basin. The details of the operation are presented in Table 4. The stage at the headwater of S-155 reached 8.49 ft at 2 a.m. on November 22, 1984. The hourly stage hydrograph with gate operations is presented in Figure 8.

TABLE 4

STRUCTURE OPERATION AT S-155

Date	Time	Action
Nov 22	0300	Richard Slyfield, Chief of Operations, was called in. Gates at S-155 were on automatic setting. Gates at S-5AE were closed to reduce inflow from L-8 basin into C-51. S-155 headwater was at 8.39 ft msl.
	0400	Open all three gates on S-155 to 5.0 ft (automatic control - off).
	0415	Three gates opened at 5.0 ft and above water. Headwater at S-155 was at 8.12 ft msl.
	0810	Headwater at S-155 at 7.70 ft msl (and was desired to be maintained at 7.0 ft msl).
	1530	Change gate operation back on automatic with lower range which is gate opened at 7.5 ft, and closed at 7.0 ft. Headwater at S-155 was below 7.0 ft msl.

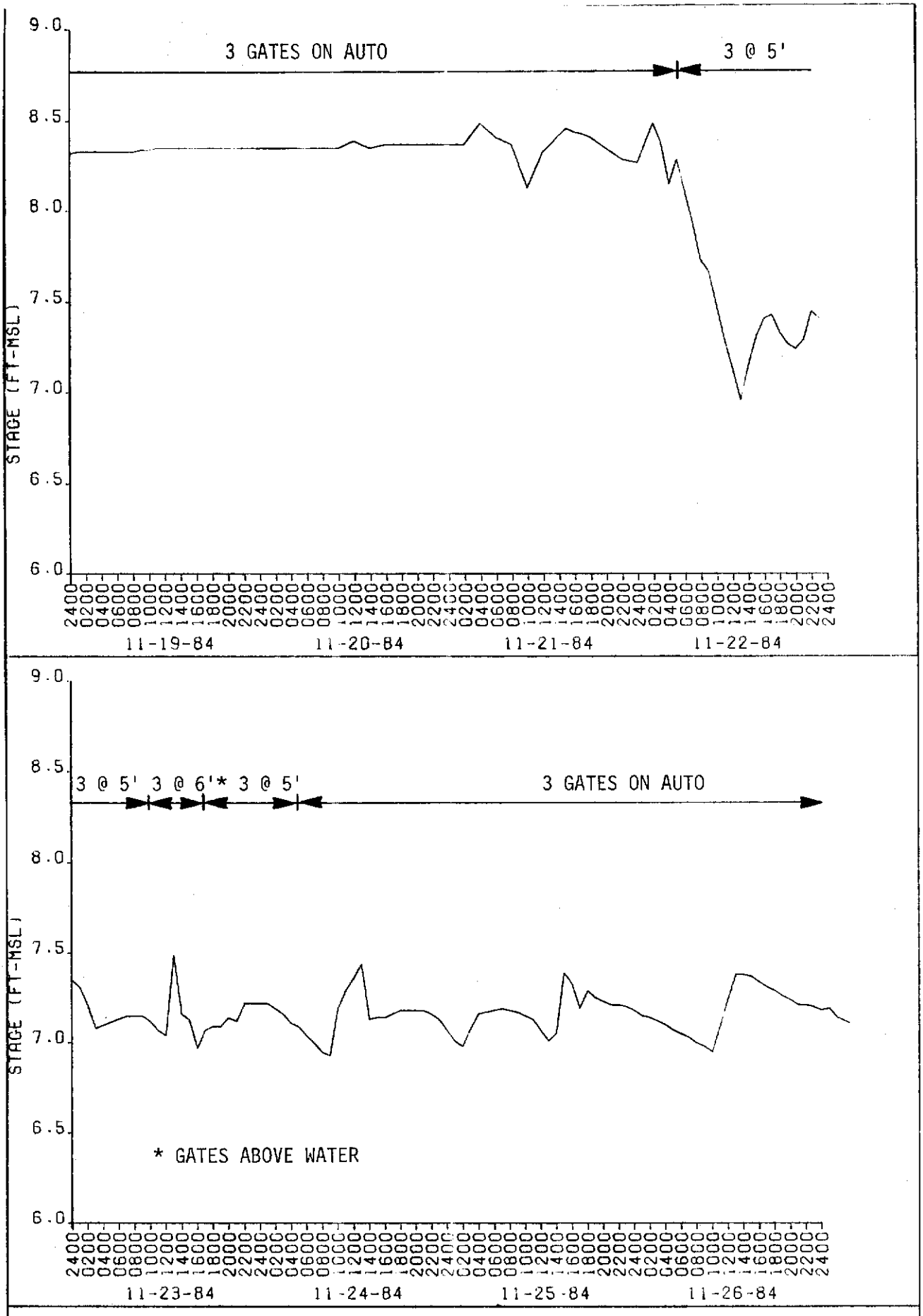


FIG. 8 HOURLY STAGE READINGS AT S-155HW

Table 4 - continued

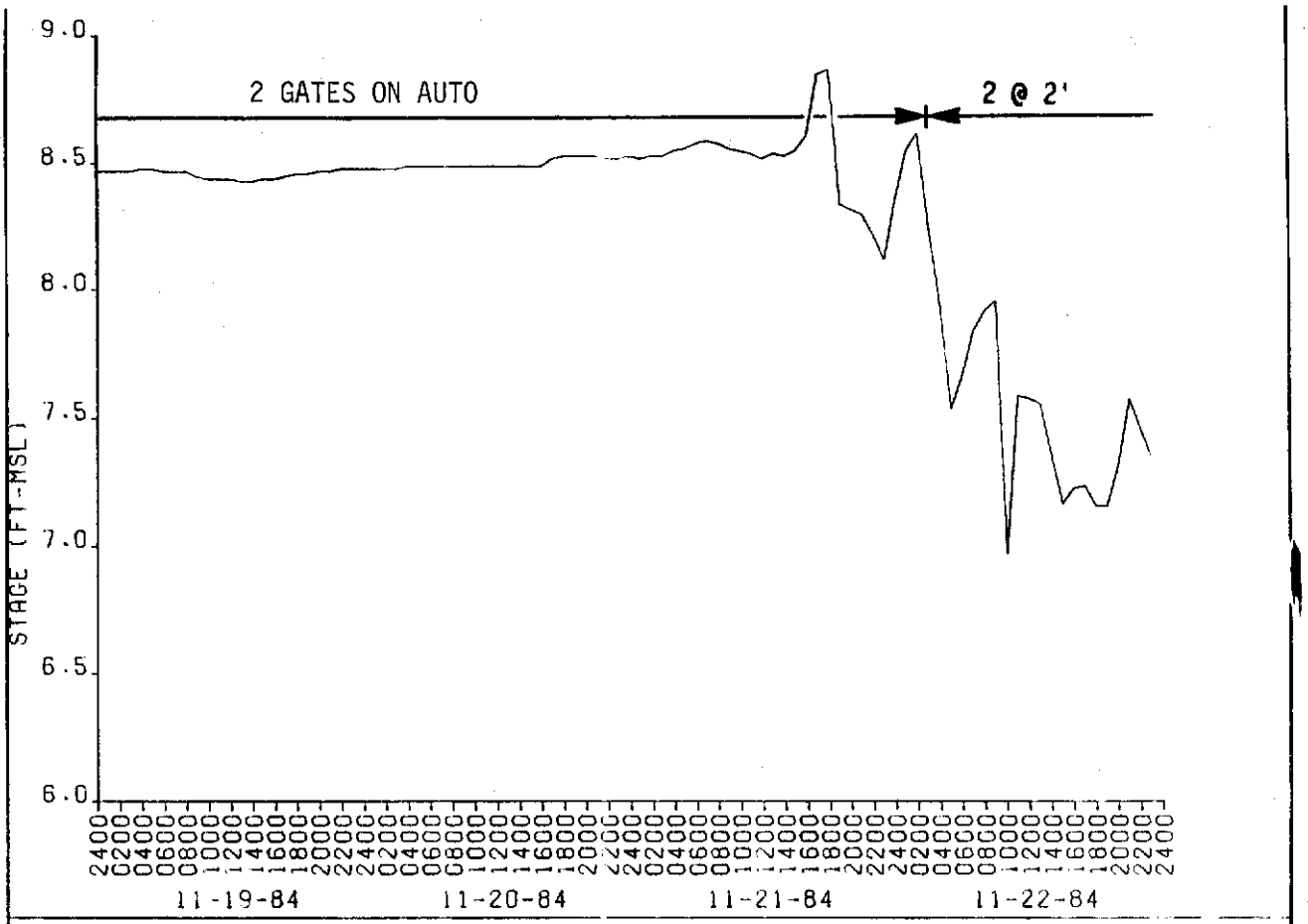
Date	Time	Action
Nov 23	1003	All three gates at S-155 were opened and above water level. Headwater at S-155 was at 7.16 ft msl. Automatic control was off and headwater maintained at 7.0 ft msl.
Nov 24	0458	Headwater at S-155 dropped below 7.0 ft msl. The gate operation back on automatic control with low range. Continue monitoring the headwater.
	1819	Gates at S-5AW and S-5AE were opened and pumped by S-5A to reduce flow in C-51 and L-8 basins.

B. S-41

This structure is a reinforced concrete gated spillway with two automatically controlled gates. This structure maintains and drains the C-16 basin which covers the area of Boynton Beach, Lake Worth, Lantana, Hypoluxo, Atlantis, etc., due to the fact that this basin is interconnected with the C-51 and C-15 basins; therefore, the same gate operating criterions as for S-155 are applied to this structure. The headwater stage was lowered to between 7.5 and 8.0 ft msl during this storm period from a normal range of 7.9 ft to 8.80 ft msl. Figure 9 shows the hourly stage hydrograph at the headwater of S-41 during this storm.

C. S-44

This structure is a 2-gated, reinforced concrete spillway structure with automatic control. It drains the area of Riviera Beach, Lake Mangonia, the eastern portion of Palm Beach Gardens, Palm Beach Mall, and westward expansion area, and several square miles west of I-95 and south of 45th Street. This area was hit hard by this storm. The gates on S-44 were on automatic control and opened fully at 0300 hours of November 22. The headwater stage was at 7.27 ft msl and reached its peak of 9.21 ft msl at 1740 hours, November 23. The estimated peak flow was about 2250 cfs.



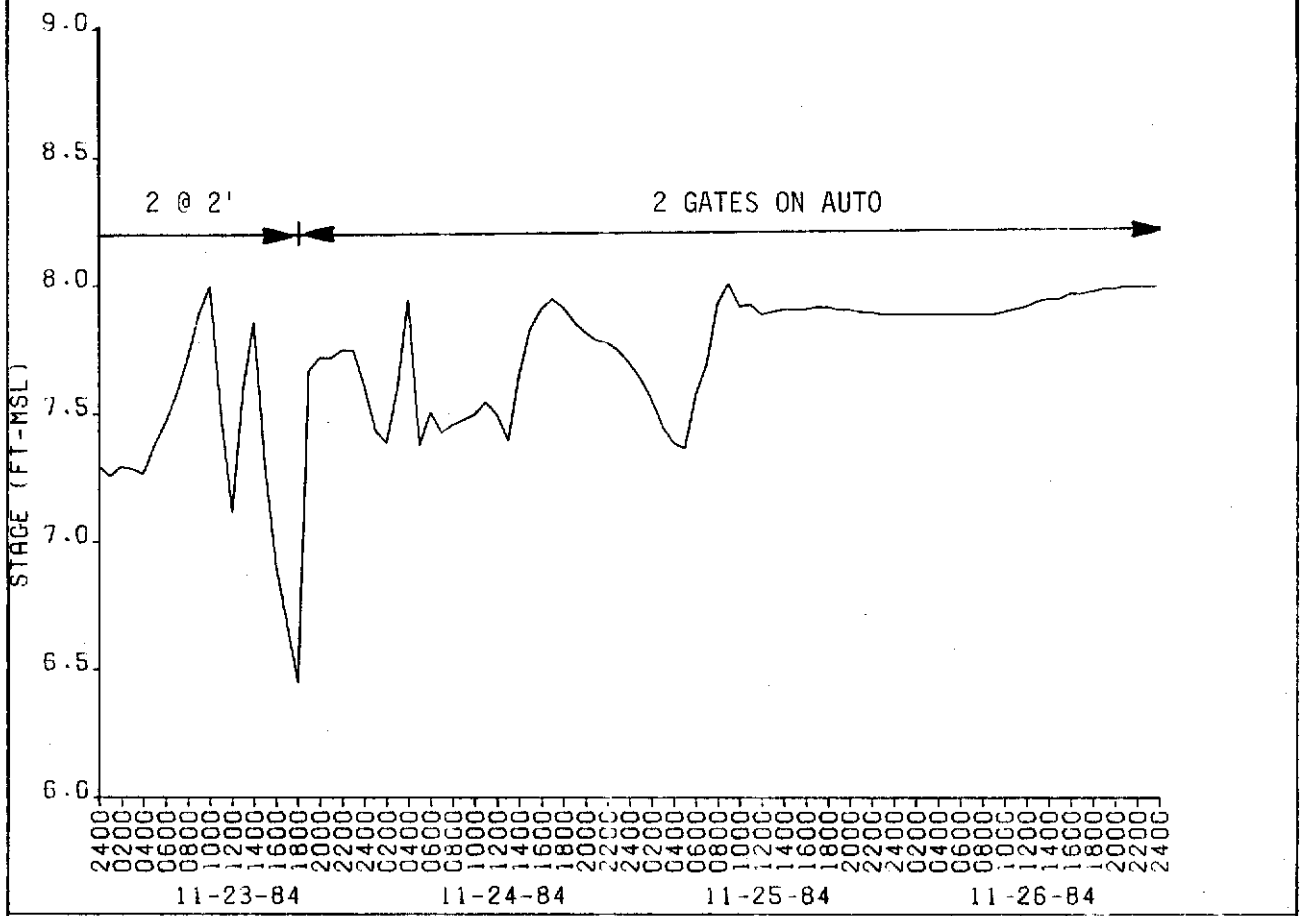


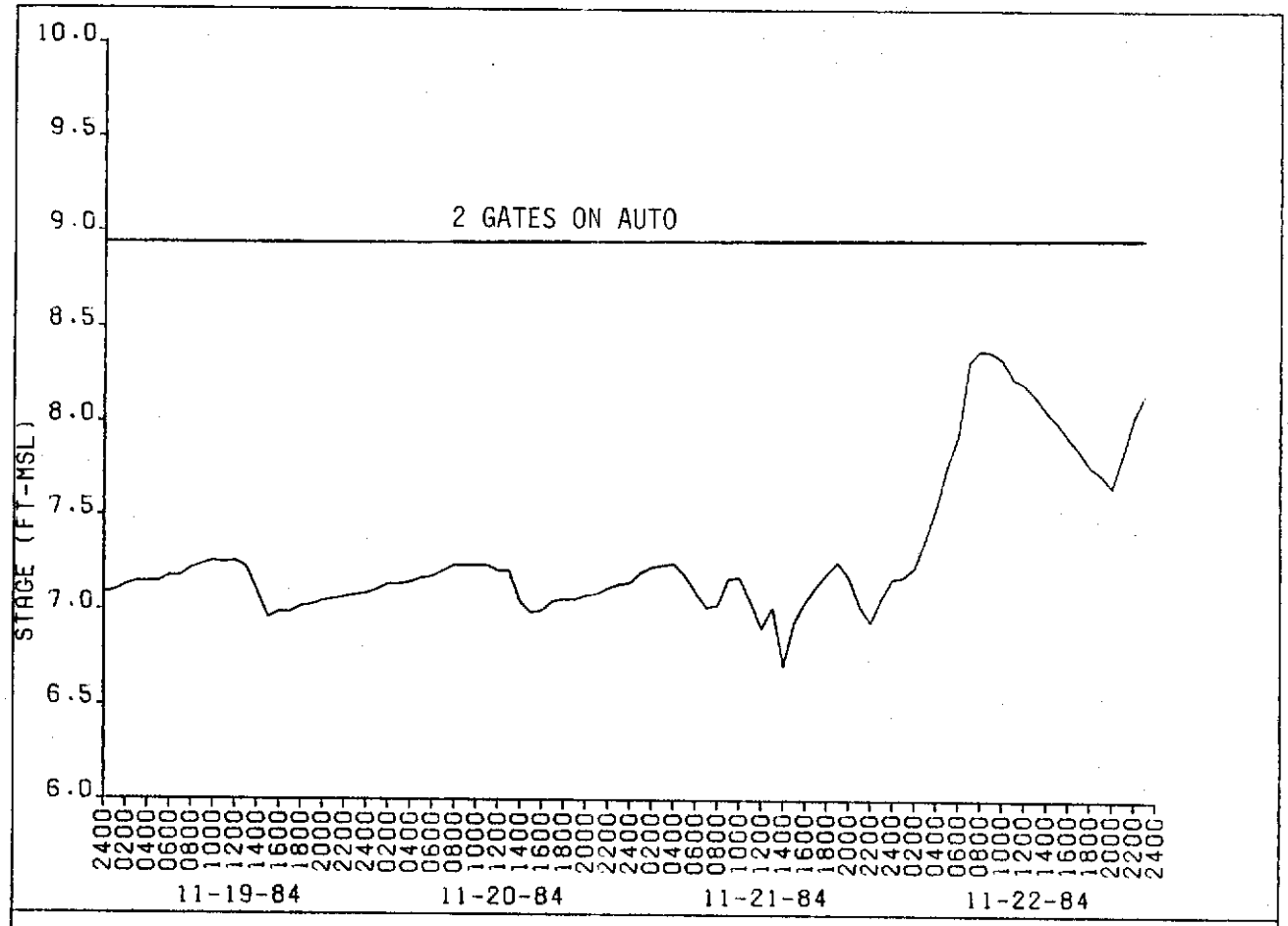
FIG. 9 HOURLY STAGE READINGS AT S-41HW

This exceeded its design capacity of 2070 cfs. Figure 10 shows the hourly stage hydrograph with gate operations during this storm period.

D. S-46

This is a gated, reinforced concrete spillway structure with three automatic control vertical lift gates. It drains the C-18 basin which covers a portion of the Corbett wildlife area, Pratt & Whitney, and the Loxahatchee Slough. Portions of this basin received the highest rainfall amount.

The gates were on automatic and maintained the headwaters of S-46 at 14.5 ft to 15.0 ft msl. At 0530 hours November 22, the No. 2 gate was not operating properly and was repaired by the District's electrician. The stage was maintained at 14.5 to 15.0 during November 22. At 2200 hours November 22, the upstream and downstream stages at C-18 weir located just north of Beeline Highway bridge, were at 18.6 and 16.0 ft msl respectively. The critical downstream stage at the C-18 weir is 17.6 ft msl. In response to the heavy rainfall along the coast, the S-46 headwater was lowered to 13.0 ft msl in the morning of November 23. The upstream and downstream stages at the C-18 weir were 18.55 and 16.54 ft msl, respectively, at 1123 hours November 23. The gates at S-46 were maintained on manual until 1300 hours November 24. The headwater stage was put back on automatic low setting to maintain stage between 13.0 to 14 ft msl. Figure 11 shows the hourly stage hydrograph with gate operations.



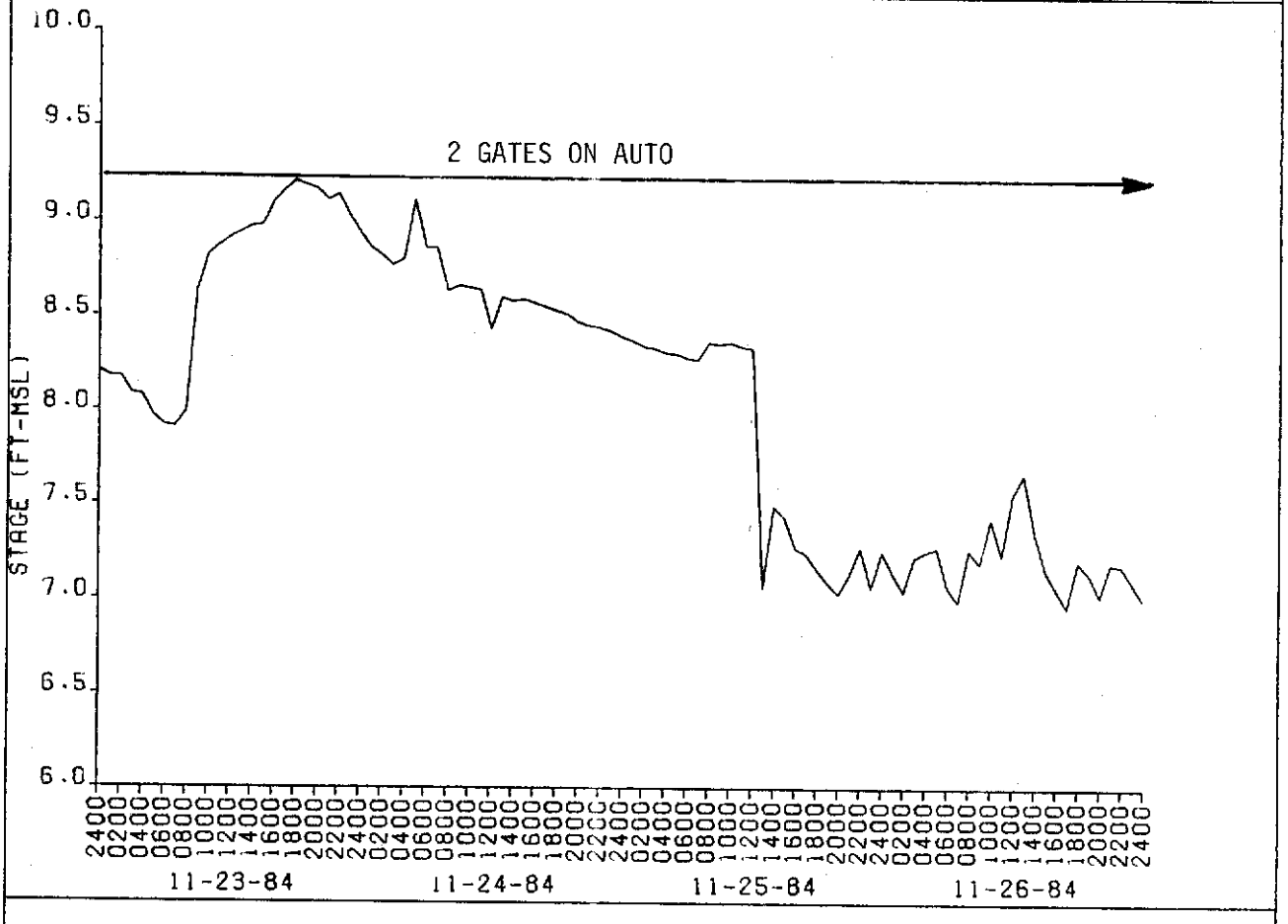
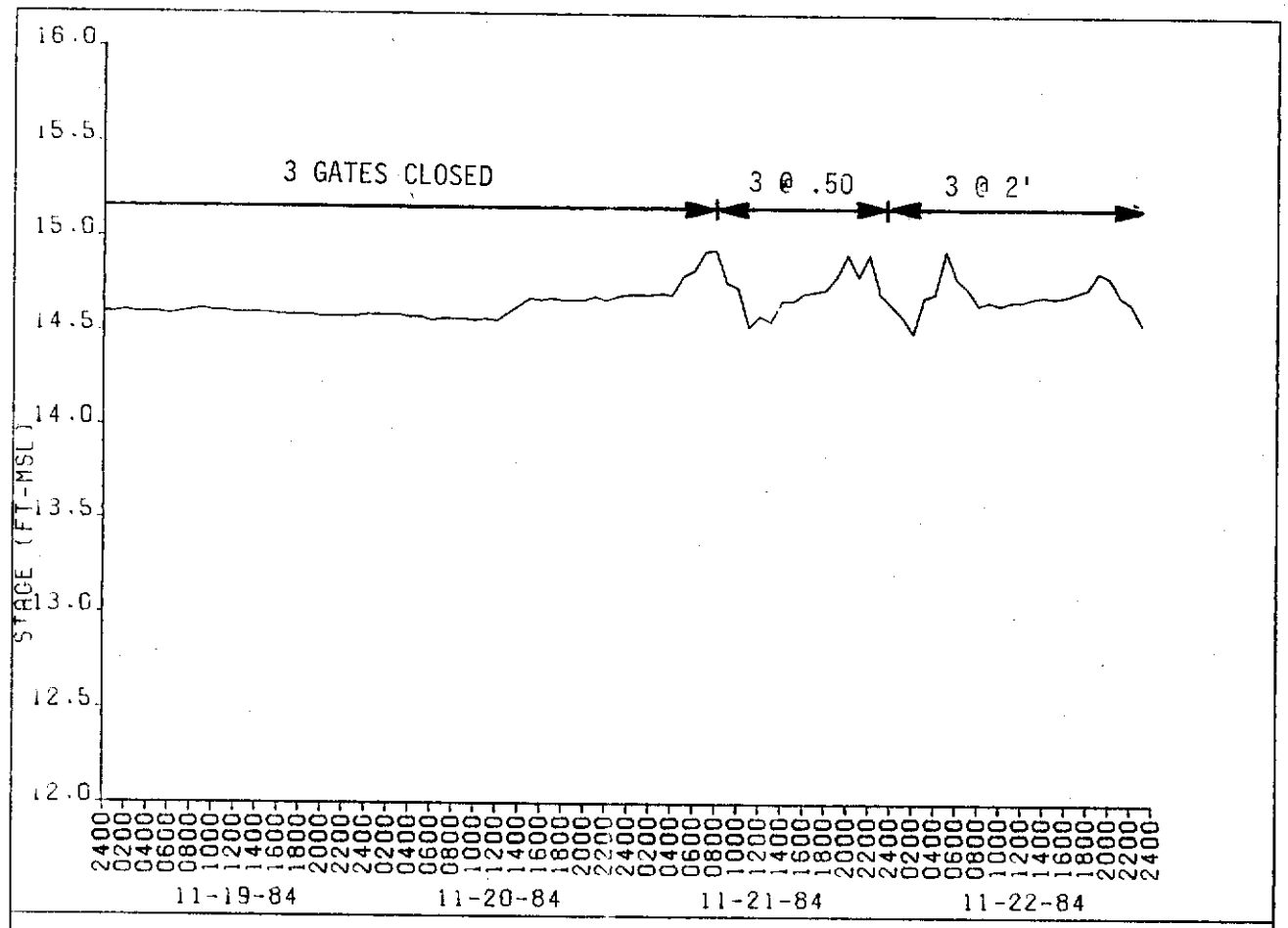


FIG. 10 HOURLY STAGE READINGS AT S-44HW



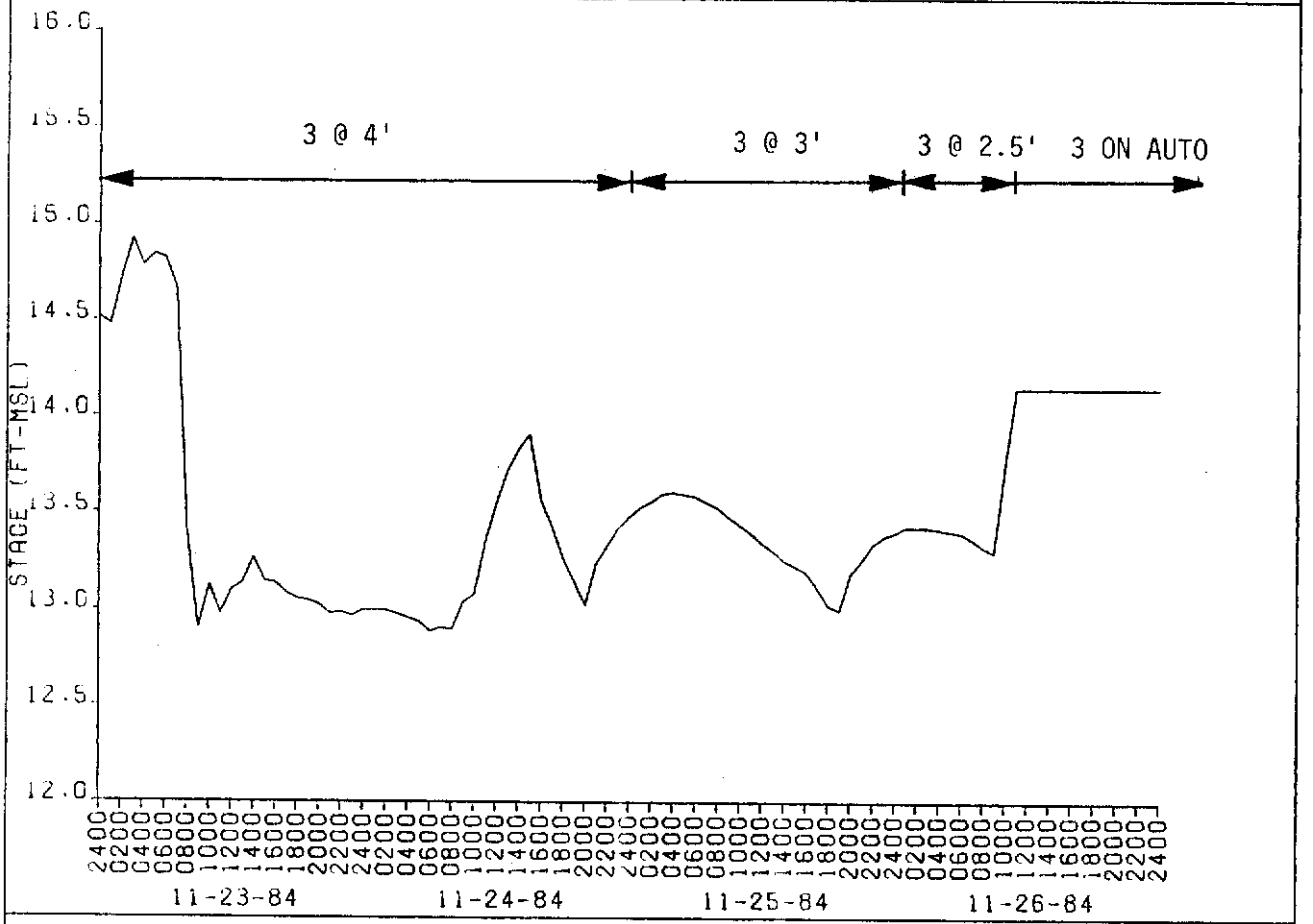


FIG. 11 HOURLY STAGE READINGS AT S-46HW

FIELD INSPECTION OF AFFECTED AREAS

The District began receiving flooding complaints via telephone at 0200 hours on November 22. The last complaint was logged in at 1000 hours on November 23. All of the telephone complaints which were received pertained to flooding within Palm Beach County. The following narrative describes the results of the field investigations which were performed, during the storm event, in response to the following complaints.

Seminole Colony Mobile Home Park (Figure 12)

Seminole Colony is located approximately three-eighths of one mile east of Military Trail on the north side of Okeechobee Boulevard. It was inspected at 0907 hours on November 22. Extensive lot and road flooding was observed throughout the project. Water approximately 2 feet deep was observed along the centerline of the entrance road to the park. At least one trailer was flooded. District field representatives were told by residents of Seminole Colony that the mobile home park drains directly into the Northern Palm Beach County Water Control District (NPBCWCD) canal which is located approximately one-half mile north of the park. Locating and inspecting the park's drainage system was not possible due to the areal extent of the flooding. There are several factors which could have contributed to the flooding. The park is at a low elevation relative to a commercial warehouse project under construction, immediately adjacent to Seminole Colony, on the west side. In addition, debris lines indicated that water had sheetflowed from Okeechobee Boulevard north into the project. Finally, the NPBCWCD canal which received water from the project appeared to be at capacity.

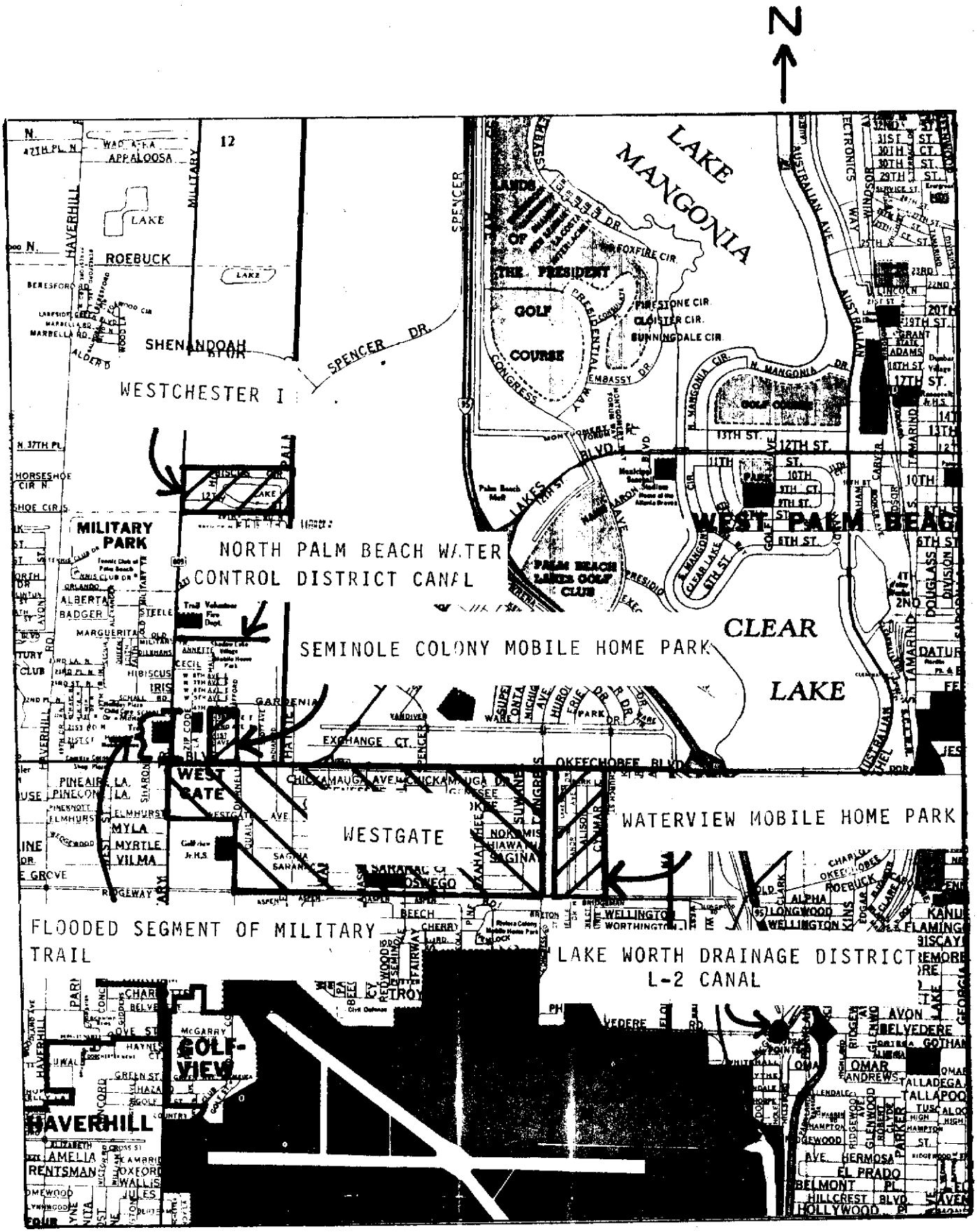


FIGURE 12 LOCATION OF WESTCHESTER I, SEMINOLE COLONY MHP, WESTGATE, WATERVIEW MHP, NPBWCD CANAL, LWDD L-2 CANAL, AND FLOODED SEGMENT OF MILITARY TRAIL

Military Trail (Figure 12)

Flooding occurred on Military Trail in the vicinity of the Military Trail School, just north of Okeechobee Boulevard. This area was inspected at 0925 hours on November 22. Water extended to the western edge of the northbound lane for a distance of approximately 400 ft. This water was a couple of inches deep and did not prevent traffic from using the roadway.

North Palm Beach Water Control District Canal (Figure 12)

This canal follows an east-west alignment and drains into the EPB-11 canal. It is located approximately 0.5 mile north of Okeechobee Boulevard and runs along the south side of the Northwood Institute. At 0926 hours on November 22, the canal stage was observed to be about 1 foot below the top of the south bank and was even with the elevation of the north bank. Water was observed to be sheetflowing into the canal through the undeveloped areas along its south bank.

This canal was inspected again on November 23 at 1349 hours, and the stage was found to have dropped 0.5 foot from the day before.

Westchester I (Figure 12)

This area was constructed under General Permit No. 81-36, and is located one mile north of Okeechobee Boulevard on the east side of Military Trail. The area was inspected at approximately 0935 hours on November 22. The detention lake stage was over the banks. A water depth of 0.5 foot was measured over the centerline of Woodstock Drive at the entrance to the development. No house pads were flooded; however, the road flooding was extensive. The operation of the development's water control structure could not be evaluated since high water stages in the NPBCWCD system prevented the water from draining.

This area was inspected again on November 23 at 1353 hours. The water depth, over the road centerline, was 0.2 foot higher than the day before.

Waterview Mobile Park (Figure 12)

Waterview Mobile Park is a development located on the south side of Okeechobee Boulevard, approximately 500 feet east of Congress Avenue. This area was inspected at approximately 0955 hours on November 22. The majority of the roads in the project were under water. Several automobiles were flooded. At the time of inspection, water was 1.6 feet deep over the centerline on Manor Avenue. Watermarks indicated that several mobile homes had been flooded hours earlier. The drainage system within Waterview Mobile Park consists of a series of drop inlets, aligned along an inverted road crown, which drains into Lake Worth Drainage District (LWDD) Lateral Canal No. 2 (L-2). At the time of inspection, the water in the L-2 canal was out of its banks.

Lake Worth Drainage District L-2 Canal (Figure 12)

This canal follows an east-west alignment and is located approximately one-half mile south of Okeechobee Boulevard. This canal eventually drains into C-51. The L-2 canal was inspected at 1023 hours on November 22 at the point where it passes under Belvedere Road. At that time, the stage within the canal was 5.8 feet below the bottom of the electrical conduit on the south side of the bridge. The observed flow was in a southerly direction.

Westgate (Figure 12)

This development is located east of Military Trail, between Belvedere Road and Okeechobee Boulevard. It is bounded on the east by Congress Avenue. This area was inspected at approximately 0900 hours on November 22. General road flooding was observed throughout the entire community. Intersections along Westgate Avenue had water standing 2 feet deep. The roadway and parking lot

of the Westgate Community Center were under water. Several homes in the area were observed to have water inside. The Westgate school grounds were flooded with water to within 1 inch of the floor elevation. Water in the LWDD L-2 canal was flowing with a stage 3 feet below the top of the bank.

Glen Ridge (Figure 13)

Glen Ridge is a development near the southwest corner of I-95 and Southern Boulevard. This project was inspected at 1032 hours on November 22. Road flooding was observed in several areas of the development. Several homes appeared to have water inside. Glen Ridge has a drainage system which depends on a pump. At the time of the inspection, District field representatives were told that the pump had been inoperable for about 1.5 hours.

Sandhill (Figure 14)

Sandhill is a development located east of I-95 and south of Northlake Boulevard. It was inspected at 1413 hours on November 23. The project's retention area was not full, and the roads and swales were dry. An additional retention area, which is shared with the Villages of Northpoint, had approximately 0.2 foot of water over its banks.

Villages of Northpoint (Figure 14)

This development is located just east of Sandhill. It was inspected at 1415 hours on November 23. Flooding was observed along some of the roads. The retention area shared with Sandhill was out of its banks.

Lone Pine Estates (Figure 14)

This development is located west of Military Trail, north of 45th Street. It was inspected the afternoon of November 23. Flooding was extensive. At least one home was flooded. No discharge to EPB-9 and 10 canals was possible due to high water stages in those canals.

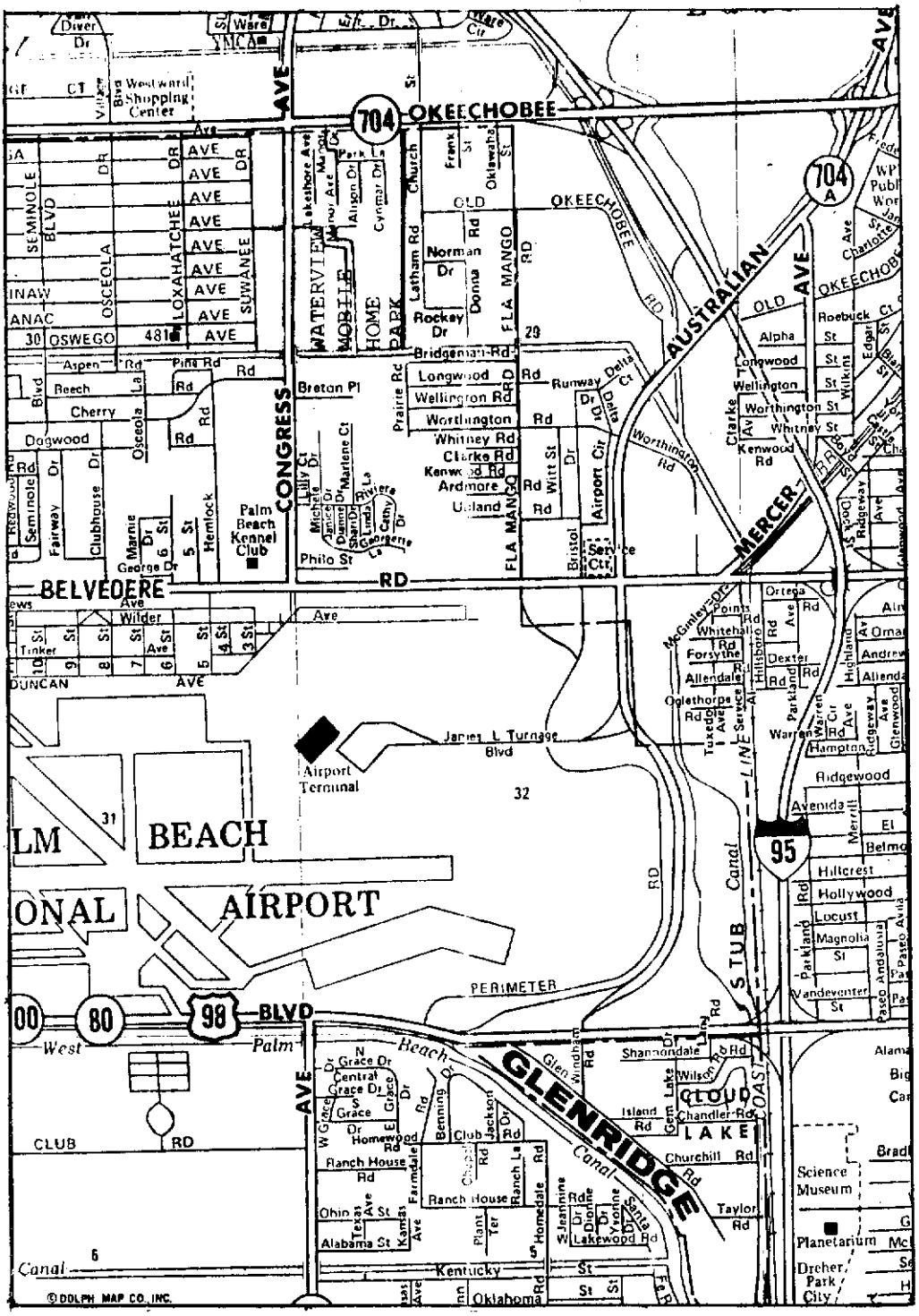


FIG. 13 LOCATION OF COMMUNITY OF GLEN RIDGE and WATERVIEW MOBILE PARK

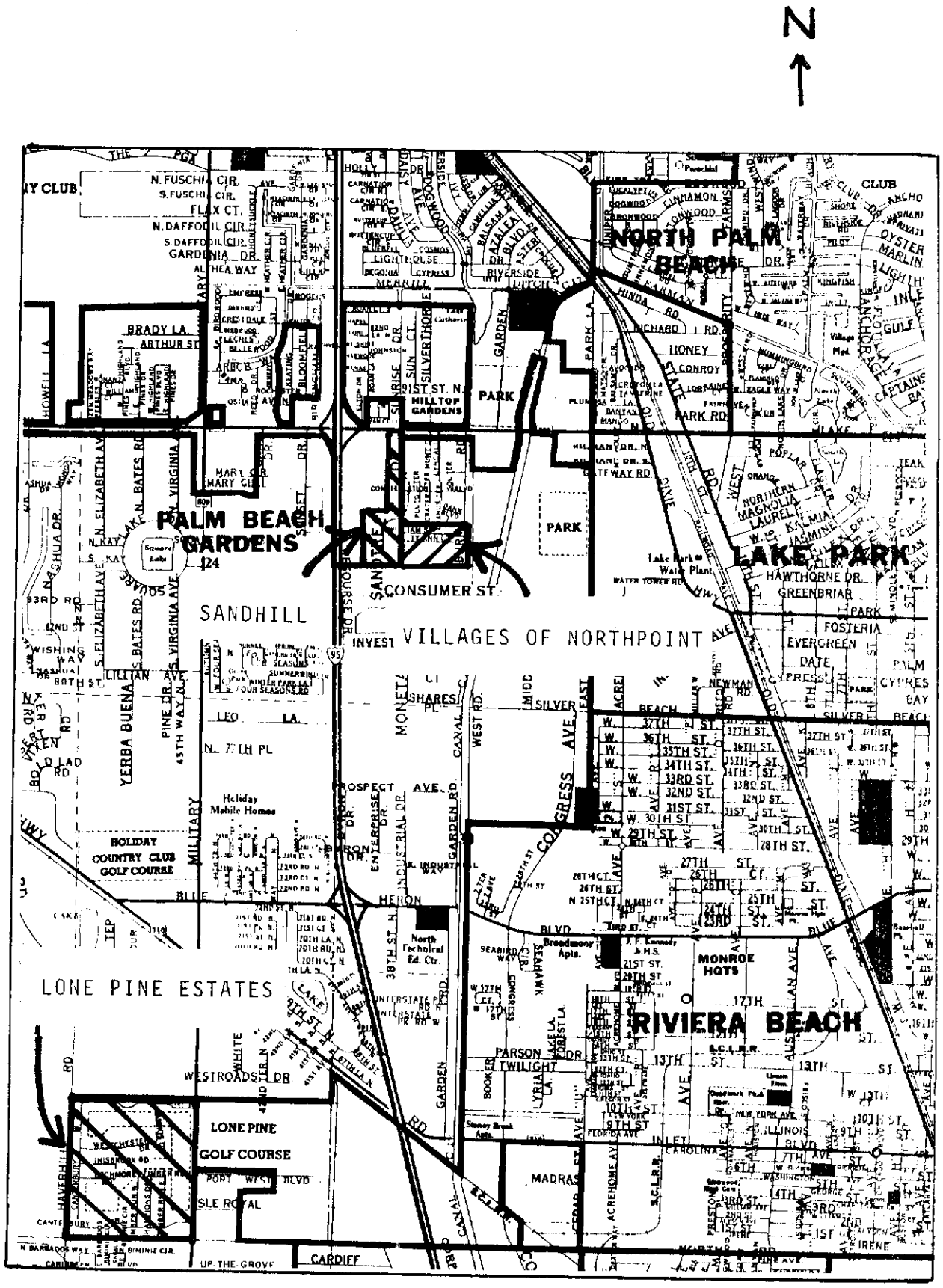


FIGURE 14 LOCATION OF SANDHILL, VILLAGES OF NORTHPOINT AND LONE PINE ESTATES

PGA National (Figure 15)

This development is located near PGA Boulevard and the Florida Turnpike. It was inspected at 1451 hours on November 23. Some road flooding was evident throughout the project. A PGA employee indicated that the pumps which drain the project were running and that the lake stage dropped approximately 0.6 foot since 0830 hours.

Royal Palm Beach (Figure 16)

This area is located west of SR-7 and north of SR-80. This community was inspected during the afternoon of November 23. Some minor yard and street flooding was observed. The stage in the M-1 Canal of the Indian Trail Water Control District was 3 to 4 feet higher than the stage in C-51 at the Amil gate, the main outlet of Royal Palm Beach Village.

The Palm Club (Figure 17)

This development is located east of Military Trail, north of Okeechobee Boulevard. It was inspected on the afternoon of November 23. Street flooding was evident. Several vehicles had water in them. Ingress and egress from the development was hazardous. The retention areas were over their banks. No homes were flooded. The water control structure for the project appeared to be impacted by the stage in northern Palm Beach County WCD canal "EPB 11-S", which is the receiving body for the project.

Lakeside Green (Figure 17)

This development is located north of the Palm Club, between Military Trail and Haverhill Road. It was inspected the afternoon of November 23. Street flooding was evident but passable. This project discharges to EPB-11.

Dyer Boulevard Landfill (Figure 18)

This area is located at the southeast corner of Beeline Highway and Florida Turnpike. It was inspected on the afternoon of November 23. Turbid

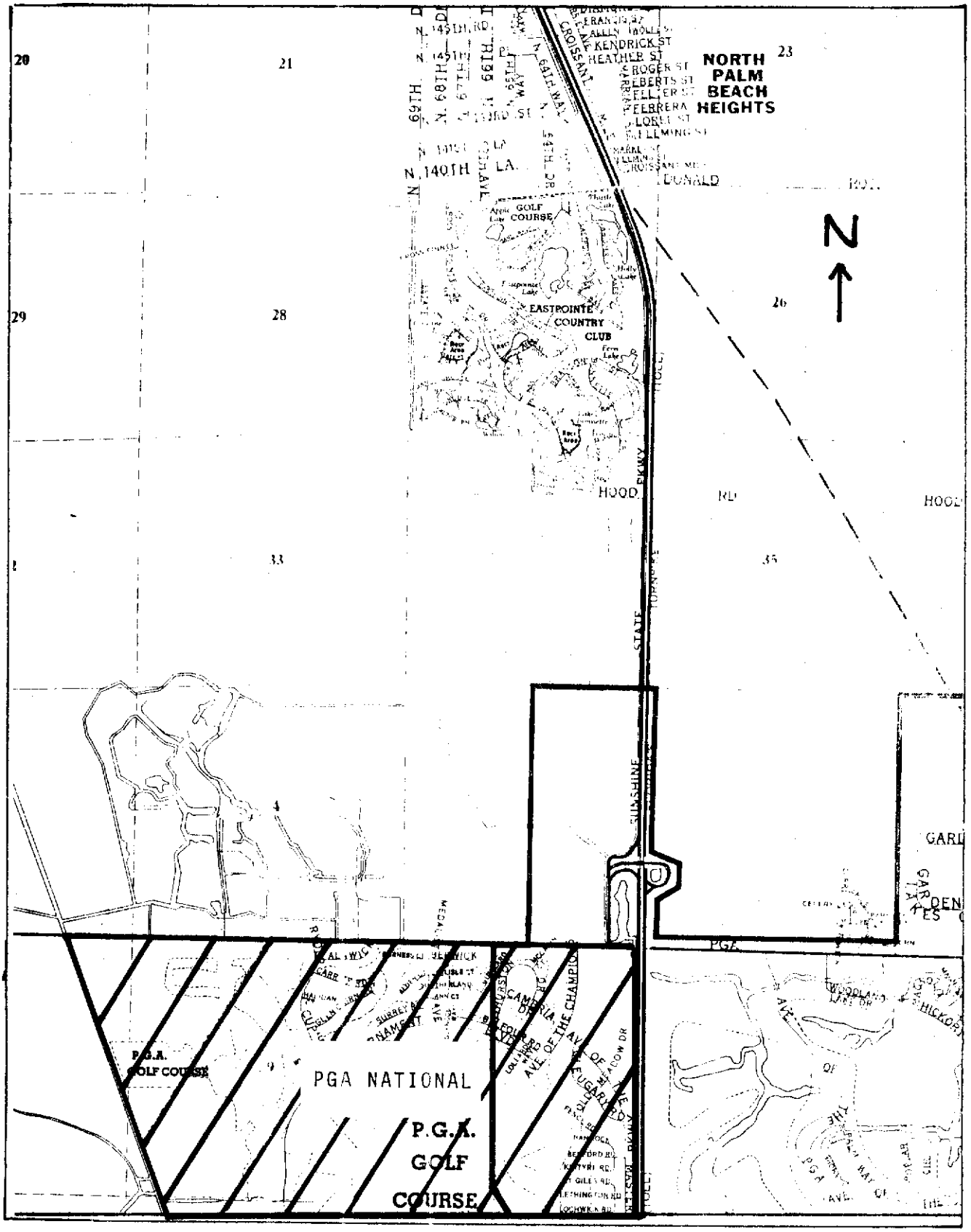


FIGURE 15 LOCATION OF PGA NATIONAL

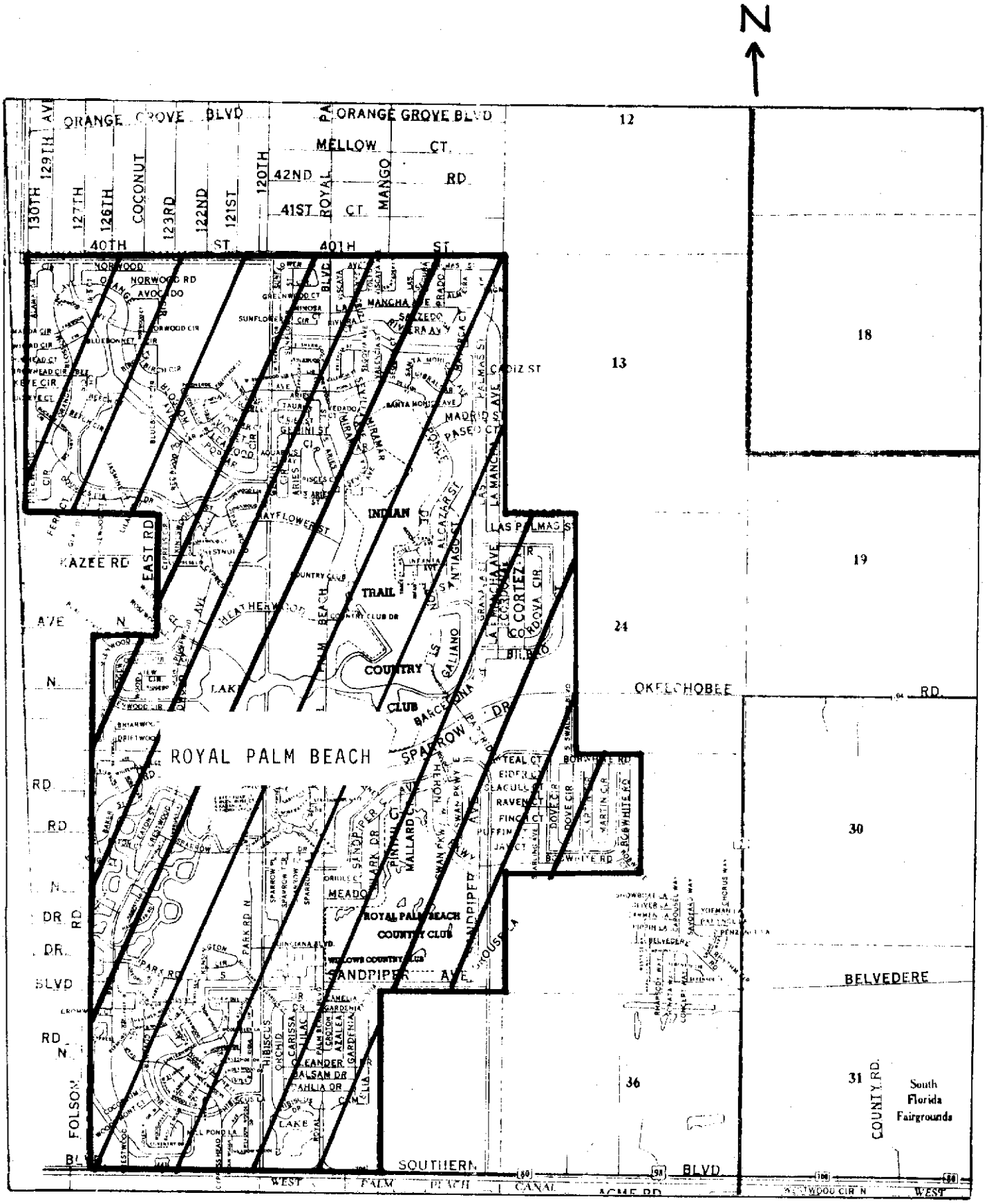


FIGURE 16 LOCATION OF ROYAL PALM BEACH

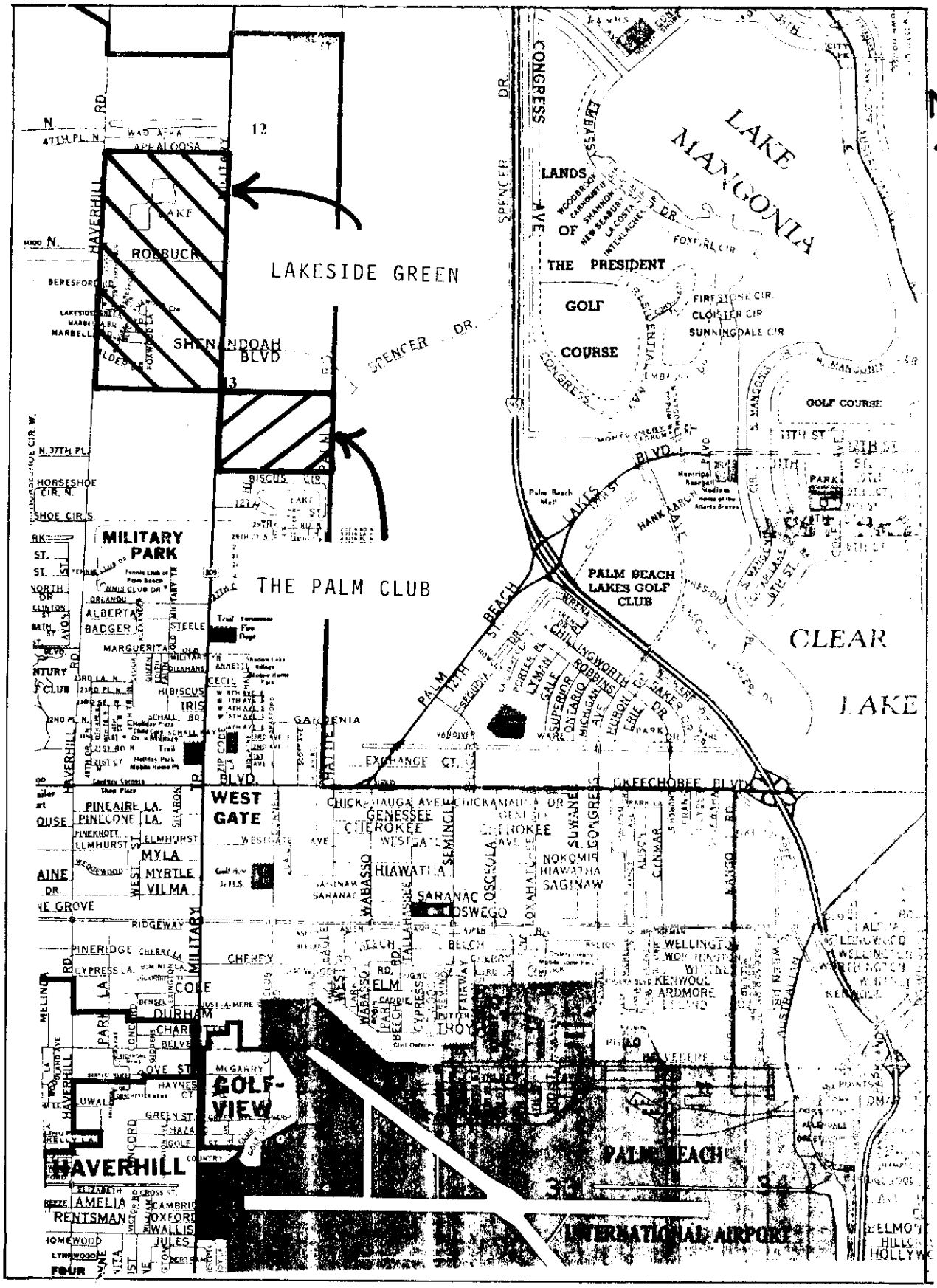


FIGURE 17 LOCATION OF LAKESIDE GREEN AND THE PALM CLUB

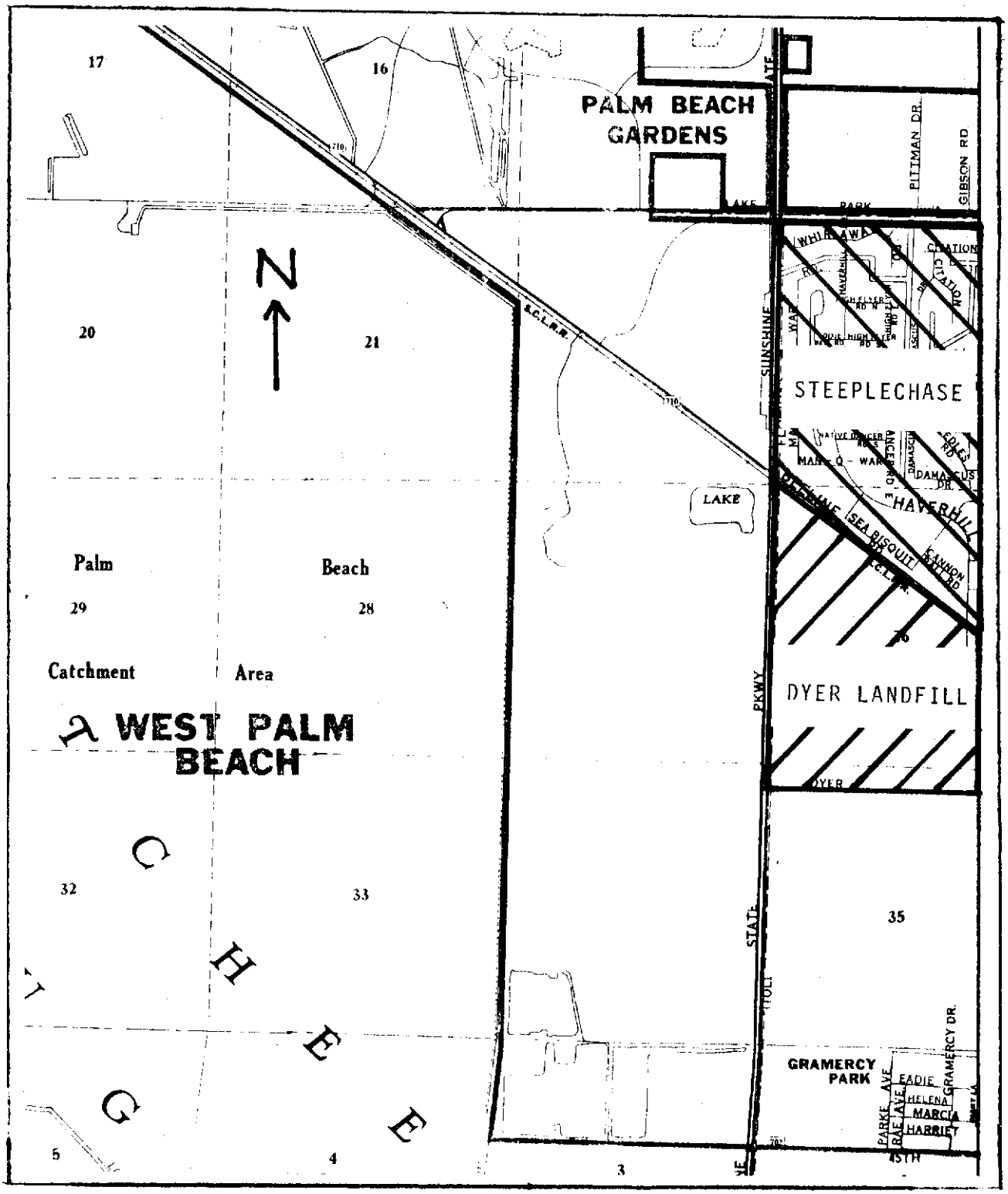


FIGURE 18 LOCATION OF STEEPLECHASE AND DYER LANDFILL

discharge was observed at the control structure. The retention area was full. Erosion was occurring on the landfill side slopes. The raw sewage pits appeared to be secure.

Steeplechase (Figure 18)

This development is located north of Beeline Highway and east of Florida Turnpike. It was inspected the afternoon of November 23. Water was observed to be 2.5 ft deep over some roads. No homes were flooded.

Eagles Nest (Figure 19)

This development is about 2 miles south of the Town of Jupiter, west of Military Trail. At the time of inspection (November 23), the retention area had equalized with its outfall. Street flooding was observed in two locations.

Jupiter Farms (Figure 20)

This community is located south of Indiantown Road and west of the Florida Turnpike. It was inspected on the afternoon of November 23. Most roads were passable. There was standing water in yards and fields.

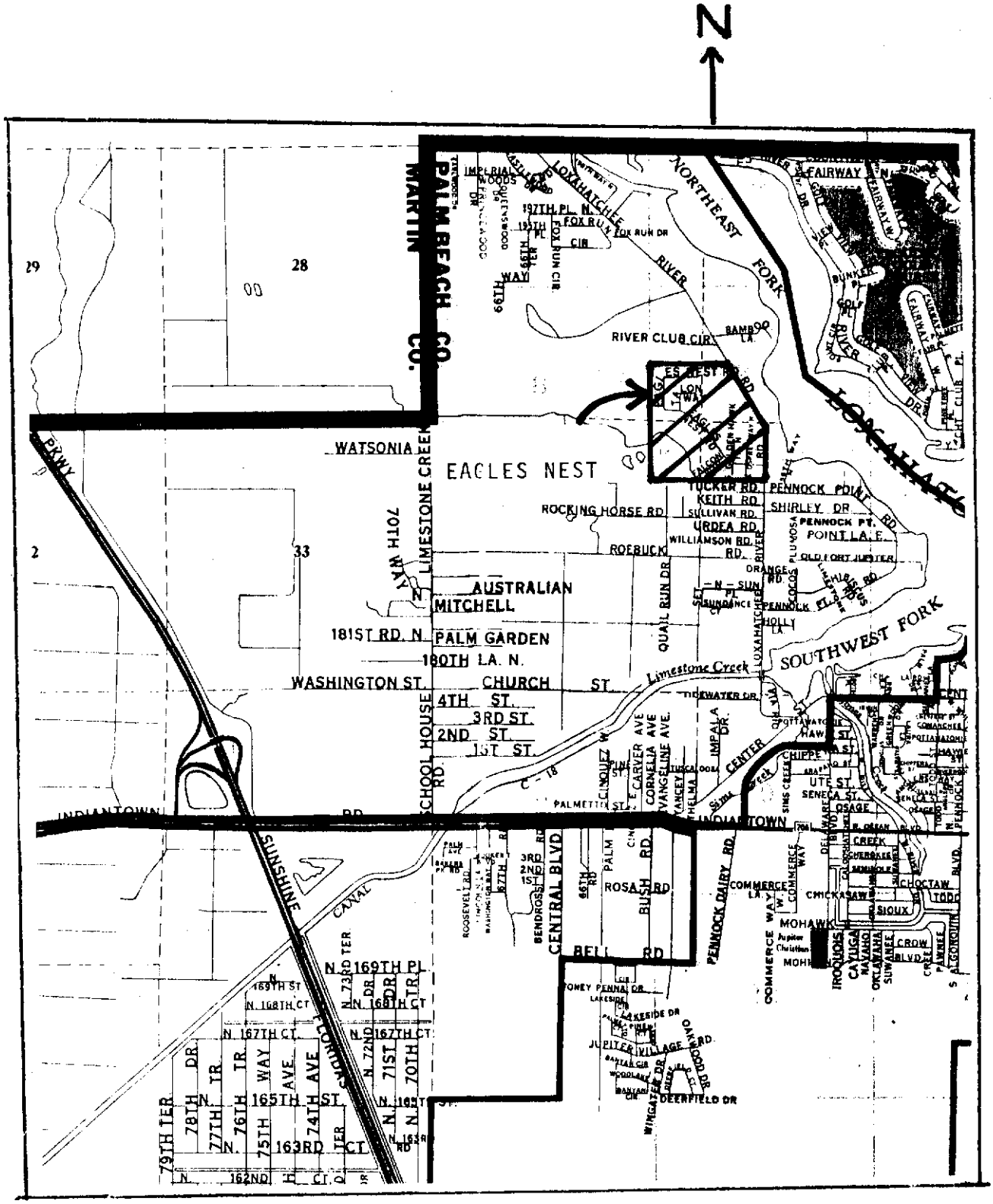


FIGURE 19 LOCATION OF EAGLES NEST

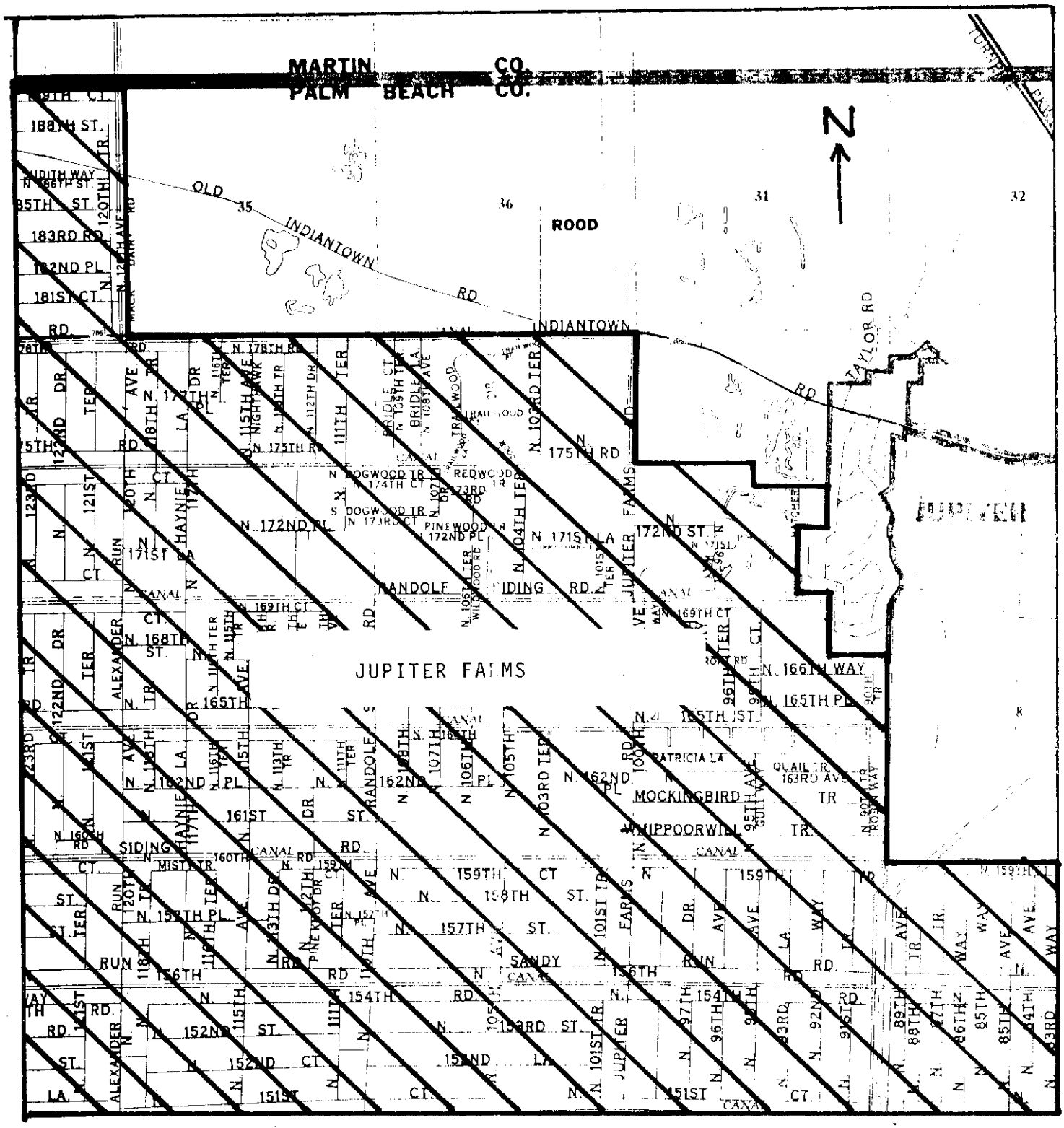


FIGURE 20 LOCATION OF JUPITER FARMS

SUMMARY OF RAINFALL EVENT

The very heavy rainfall which occurred during November 21 through November 26 was due to a slowly moving, intense low pressure center located off the southeast Florida coast. Heavy rains to the north side of the low pressure center caused the flooding of homes and streets, particularly in a region from Lake Worth extending northward to the Jupiter area. A weather watcher in Jupiter reported over 19 inches of rainfall during this storm event. This rainfall total has a return frequency of less than once in one hundred years. The most intense hourly rainfall was reported at the West Palm Beach Field Station where rainfall intensity was reported to be 1.99 inches an hour between 0100 and 0200 hours on November 22. The 6.67 inches recorded before sunrise on November 22, during a six hour period at this field station, was a once in ten year event. Overall, the field station received 14.6 inches of rain during this storm event.

Although rainfall measurements were very high in the Jupiter area, only minor flooding was reported. This is probably due to the extremely dry antecedent conditions in the area.

Some flood prone communities such as the Waterview Mobile Park, Westgate, Seminole Colony, and Lone Pine Estates received 12 to 13 inches of rain and some serious flooding resulted.This rainfall magnitude has a return frequency of about once in 15 to 20 years.

The new S-155 structure at the outlet of C-51 performed very well. The structure was on automatic with an antecedent headwater stage of about 8.3 ft msl. During the storm, the headwater stage was lowered to 7.0 ft to enhance the secondary drainage system. Stages in C-51 were maintained

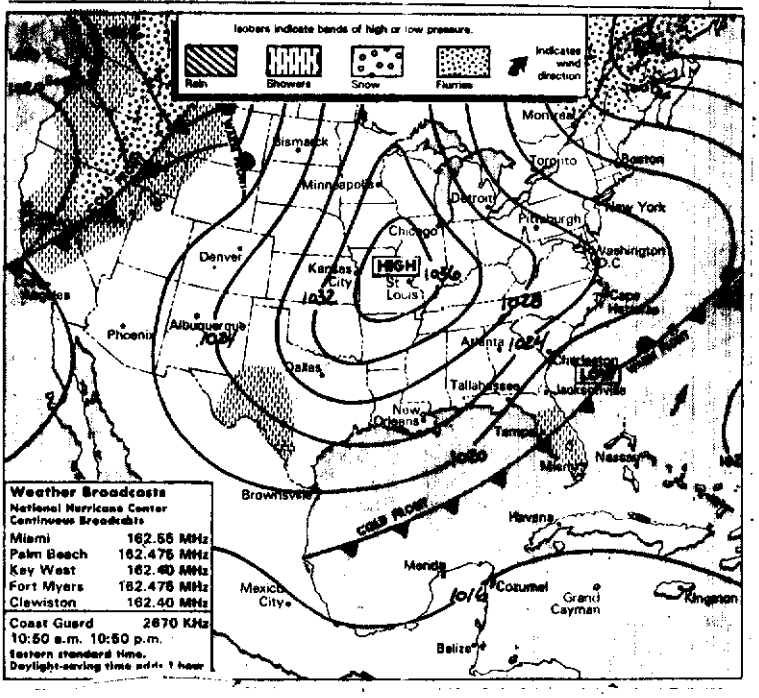
almost 2 feet lower than during the previous storms of March and April 1982 which occurred before the new structure was in place.

A review of the project system performance during this storm indicated that there were no serious problems encountered. Flooding in the Waterview Mobile Park area was caused by 1) the low elevation of the area (flood prone), 2) rainfall intensity, and 3) increasing runoff due to rapid development in the basin has surpassed the design capacity of the Stub Canal.

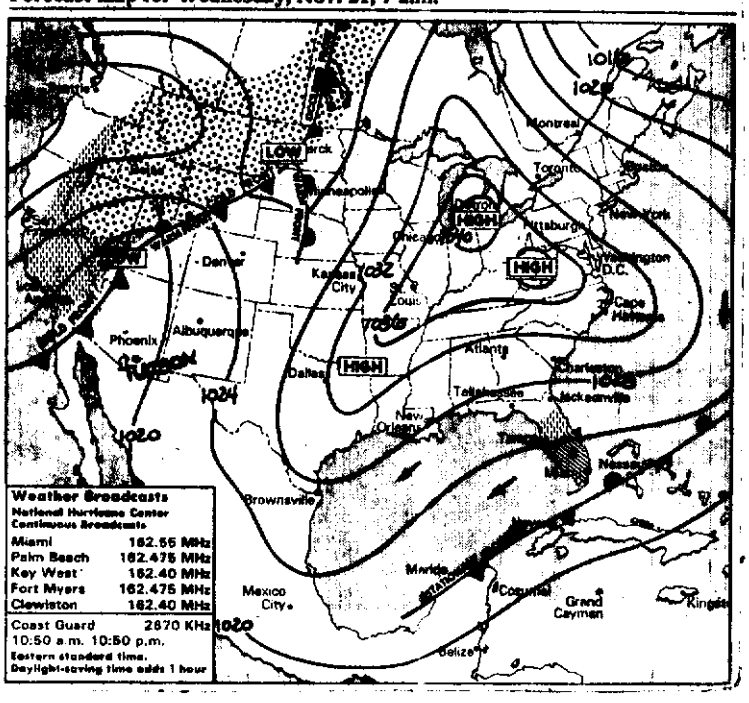
APPENDIX A

WEATHER MAPS

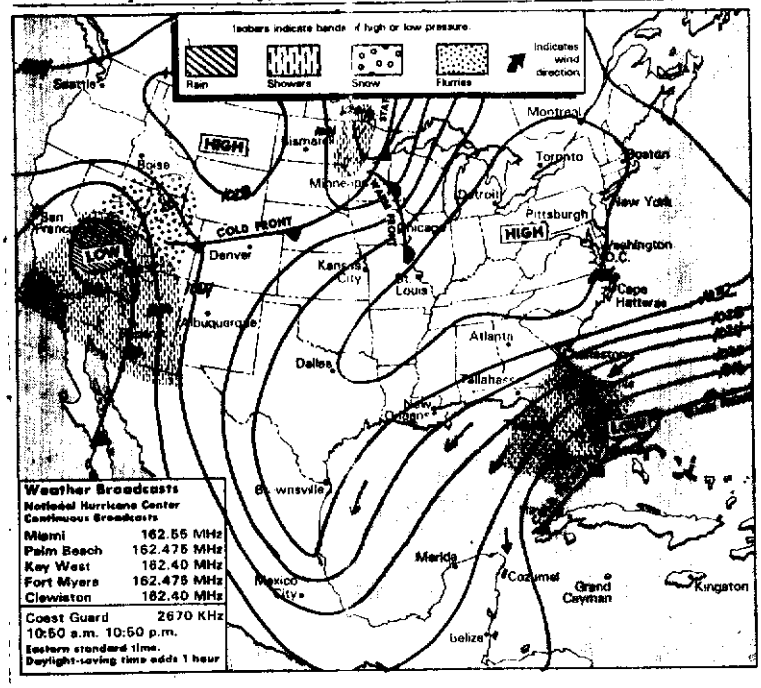
Forecast map for Tuesday, Nov. 20, 7 a.m.



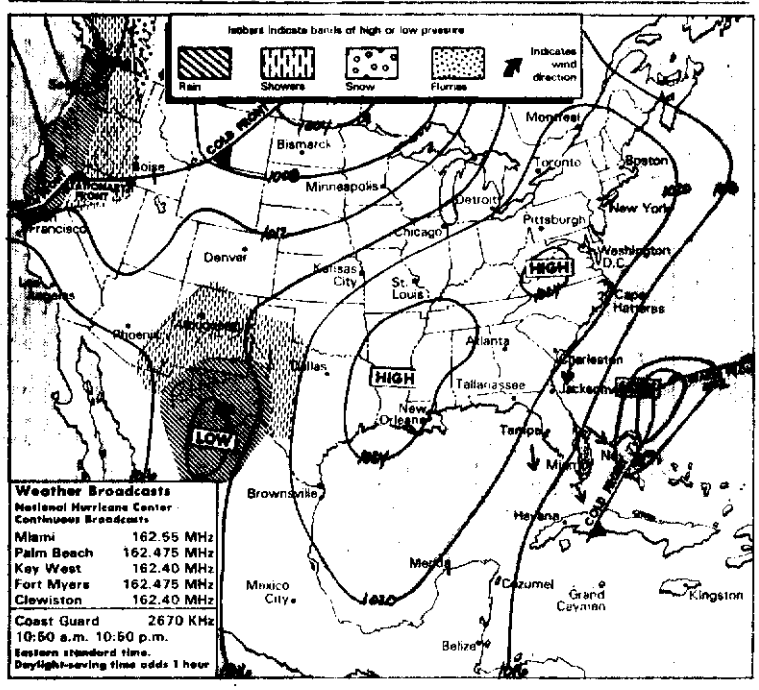
Forecast map for Wednesday, Nov. 21, 7 a.m.



Forecast map for Thursday, Nov. 22, 7 a.m.



Forecast map for Saturday, Nov. 24, 7 a.m.



APPENDIX B

SUMMARY OF THE MAJOR COASTAL DAMAGE CAUSED BY THE NOVEMBER 21-26, 1984 STORM

Location	Description
St. Augustine St. Johns County	One million dollar pier washed away.
Flager Beach Flager County	Damage to Flager Beach pier estimated to be $250,000.
Daytona Beach Volusia County	Streets washed out and severe erosion of beaches.
Cocoa Beach Brevard County	Damage to piers and dock at Sebastian Inlet State Park.
Vero Beach Indian River County	Ocean Grill Resturant and Aquarius Restuarant sustained heavy damage.
Ft. Pierce St. Lucie County	Ocean Village condominium project under water for three days.
Jensen Beach St. Lucie County	Holiday Inn damaged and the seawall washed out to sea.
Jupiter Island Martin County	Island homes damaged.
Jupiter Inlet Park Palm Beach County	Parking lot caved in.
City of Palm Beach Palm Beach County	Large sections of A1A washed away, seawall damaged, and 230 foot freighter washed up on beach.